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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 101.

L. O. HOWARD, Entomologist and Chief of Bureau.

CALOSOMA SYCOPHANTA:

ITS LIFE HISTORY, BEHAVIOR, AND SUCCESSFUL COLONIZATION IN NEW ENGLAND.

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BY

A. F. BURGESS,

Expert in Charge of Breeding Experiments.

ISSUED DECEMBER 8, 1911.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

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Rolla P. Currie, *in charge of editorial work.*
Mabel Colcord, *in charge of library.*

Preventing Spread of Moths.

PARASITE LABORATORY.

W. F. Fiske, *in charge;* A. F. Burgess, C. W. Collins, R. Wooldridge, J. D. Tothill, C. W. Stockwell, H. E. Smith, W. N. Dovener, F. H. Mosher, *assistants.*

FIELD WORK.

D. M. Rogers, *in charge;* H. B. Dalton, H. W. Vinton, D. G. Murphy, I. L. Bailey, H. L. McIntyre, *assistants.*

CALOSOMA SYCOPHANTA.

Adult eating gipsy moth caterpillar, lower left; pupa, lower right; eggs, upper left; eaten chrysalides of gipsy moth, upper right; full-grown larvæ from above and from below. (Original.)

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LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., June 3, 1911.

SIR: I have the honor to present for publication a manuscript on the subject "Calosoma Sycophanta: Its Life History, Behavior, and Successful Colonization in New England," by Mr. A. F. Burgess, of this bureau. The insect in question is one of the most important of the natural enemies of the gipsy moth and the brown-tail moth which have been imported from Europe. The work on its life history and the means of establishing it has been in Mr. Burgess's charge. He is particularly skilled in this class of work, and has achieved a notable success in this investigation.

I recommend that this paper be published as Bulletin No. 101 of this bureau.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau

Hon. JAMES WILSON,
Secretary of Agriculture.

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CALOSOMA SYCOPHANTA:

ITS LIFE HISTORY, BEHAVIOR, AND SUCCESSFUL COLONIZATION IN NEW ENGLAND.

INTRODUCTION.

It has long been known that certain predaceous beetles common in Europe belonging to the family Carabidæ, particularly *Calosoma sycophanta* L. and *Calosoma inquisitor* L., are enemies of the gipsy moth and the brown-tail moth, as well as other lepidopterous larvæ, and as soon as the work of importing the natural enemies of the first-mentioned insects into Massachusetts was begun an effort was made to secure these species for liberation.

Calosoma sycophanta (Pl. I) is a beautiful green beetle about 1 inch in length. It is provided with long legs and is able to run and climb very rapidly. The tarsal joints of the front legs of the female are dilated and spongy beneath, while those of the male are similar to those on the other legs. (See fig. 1.)

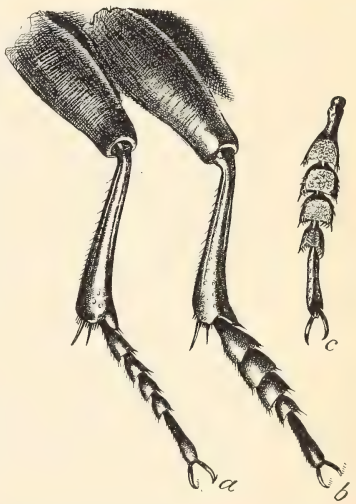


FIG. 1.—Front leg of female and of male of *Calosoma sycophanta*, showing differences in structure of front tarsal joints: *a*, Female; *b*, male; *c*, underside of male tarsus. (Original.)

In the spring of 1905 an arrangement was made between the State of Massachusetts and the United States Department of Agriculture whereby the introduction of the natural enemies of these moths was to be carried on cooperatively, and Dr. L. O. Howard, Chief of the Bureau of Entomology, was given general supervision of the work. In order to organize a corps of collectors, so that large quantities of material could be secured and promptly shipped to this country, he sailed for Europe early in the spring of that year and engaged competent entomologists in several countries to take charge of that branch of the service.

IMPORTATIONS OF CALOSOMA BEETLES FROM EUROPE AND JAPAN.

Between July 15 and August 1, 1905, 216 specimens of *Calosoma sycophanta* were received from Dr. G. Leonardi, of Portici, Italy, which were collected in Sardinia, but only one of the beetles was alive when the shipments reached the laboratory at North Saugus, Mass. The death of so many of the insects was due to their being packed in tin boxes, which are not suited to the purpose, and also to the fact that they were sent by the way of London and New York, which caused considerable delay in their arrival.

During the year 1906 shipments were received from Miss Marie Ruhl, Zurich, Switzerland, who had in her employ a large force of collectors who sent material to her, which she packed and mailed to the Gipsy Moth Parasite Laboratory. Of 25 shipments received from her, 15 contained specimens of *C. inquisitor* and the balance *C. sycophanta*. Three shipments of the latter species were also received from Dr. Leonardi, which were collected in Italy. The material was unpacked and cared for at the laboratory by Mr. E. S. G. Titus, who had been detailed by Dr. Howard to take general charge of the material imported. He was assisted by Mr. F. H. Mosher, who was employed by the State of Massachusetts in the parasite investigations. Two hundred and eighty specimens of *C. inquisitor* and 693 of *C. sycophanta* were received in living condition during the season. Several colonies were liberated in the field and the remaining specimens were confined in large cages out of doors to secure data on their habits.

During the summer of 1907, 967 live specimens of *C. sycophanta* were received. This represented less than one-half of the number shipped. The reason for the high mortality will be explained later in this paper. The first lots were cared for by Mr. Mosher, who liberated several colonies. Early in the summer Mr. Titus resigned to accept another appointment, and Mr. W. F. Fiske was placed in charge of the parasite work.

On July 21, 1907, an arrangement was made whereby the work on predaceous beetles was placed in charge of the writer, who was at that time conducting insecticide investigations for the State of Massachusetts. Mr. C. W. Collins, an employee of the State office, was detailed to assist in the beetle work and has since devoted most of his time to this work.

In the summer of 1908, 675 specimens of *C. sycophanta* were received from Miss Ruhl, and also numerous specimens of other species of Calosoma and Carabus, said to be beneficial in Europe. The latter were received in such limited numbers that little more could be done than to make life-history studies and an investigation of their food

habits. Some of these studies have shown very interesting results, which it is hoped may be published later.

Four hundred and five specimens of *C. sycophanta* were received in 1909, and in addition 25 larvæ of this species arrived in boxes with parasitized gipsy moth material. Specimens of other carabids were also sent in limited numbers.

During the summer of 1910, 1,305 living specimens of *Calosoma sycophanta* were received from Miss Ruhl and several shipments of miscellaneous species of Carabus came from the same source. For the first time since the work was begun specimens of Calosoma and allied genera were received from Japan. A very few individuals reached the laboratory in healthy condition, and these were used for rearing work.

The following table gives the number of live specimens of *C. sycophanta* received since the work began.

TABLE I.—*Number of live specimens of Calosoma sycophanta received in Massachusetts, 1905 to 1910.*

Year.	Number received.	Year.	Number received.
1905	1	1909	405
1906	693	1910	1,305
1907	967		
1908	675	Total	4,046

Sixty-seven per cent of these beetles were liberated in field colonies and the balance was used for experimental and reproduction work.

METHODS OF PACKING PREDACEOUS BEETLES FOR SHIPMENT.

Considerable difficulty is always experienced in shipping living insects long distances, especially if it is necessary to collect and forward them when they are active, and also if they must reach their destination in season to feed and reproduce without serious interruption. Species that can be packed when dormant can be easily transferred from one place to another, but it has not been found possible to do this with predaceous beetles.

In 1905, as has already been stated, the beetles imported were packed in tin boxes, and practically all of them died in transit. Two kinds of boxes were used for the purpose. One style (fig. 2) consisted of a tin box 6½ inches wide, 10½ inches long, and 2½ inches deep. It was divided in the center by a partition, and small partitions were soldered to it, so as to make 20 compartments. In each of these a beetle was placed, as well as a gipsy-moth caterpillar or pupa. The box was wrapped with stout paper and shipped by mail. On arrival it was found that the beetles had attacked the food placed in the compart-

ments, and, as the tin did not absorb the moisture, the beetles became covered with the decomposed remains and death resulted.

The other method of using a tin package was to place several beetles with larvæ for food and a small quantity of sphagnum moss in each box. The results, however, were not satisfactory.

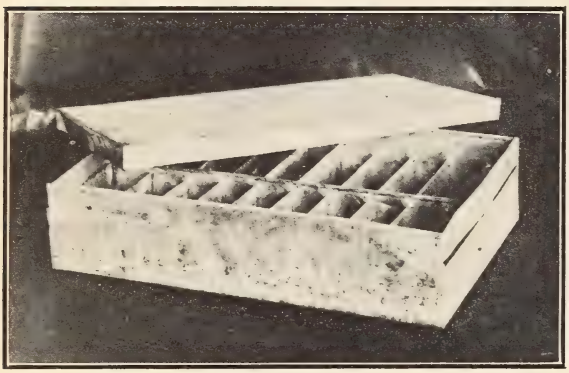


FIG. 2.—One of the tin boxes used for making the first shipments of Calosoma beetles. (Original.)

In the spring of 1909 several lots of the native beetle *Calosoma scrutator* were shipped to the laboratory from Washington, D. C. They were packed separately in small tin boxes with a little wet sphagnum moss and arrived in good condition. No food was put into the boxes, and the beetles were received in less than 48 hours from the time they were collected.

In 1906 the European material was shipped in wooden boxes instead of tin. These boxes (fig. 3) were made of $\frac{1}{4}$-inch stock, the usual size being $7\frac{1}{4}$ by 4 by $2\frac{1}{4}$ inches. Inside of these were packed match boxes, such as are used for safety matches, each of which contained a small quantity of sphagnum moss and a single beetle. (See fig. 4.) Occasionally two beetles were placed in a match box, but better results were secured when only one was inclosed. By using this method of packing and placing wet moss in the boxes the mortality during shipment for the year 1906 was 15 per cent in the case of *Calosoma sycophanta* and 38 per cent in that of *Calosoma inquisitor*. In 1907 no specimens of *C. inquisitor* were received, and 54 per cent of *C. sycophanta* died in transit. This was principally due to the moss being very dry in the boxes

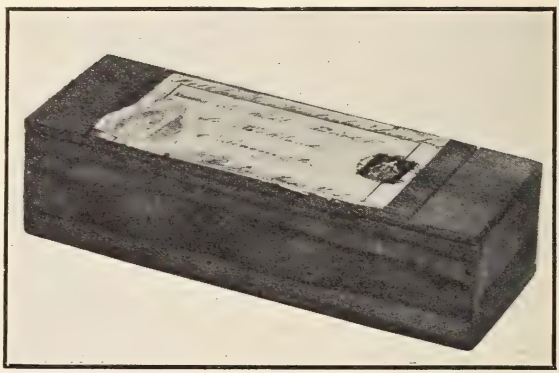


FIG. 3.—One of the wooden boxes used for shipping Calosoma beetles from Europe. (Original.)

and also because in many of the shipments sawdust was used instead of moss, and proved unsuitable for the purpose. At the close of that year instructions were sent that in the future wet moss should be placed in the match boxes with the beetles, and since that time the rate of mortality has been reduced. In 1908 only 14 per cent and in 1909 9 per cent of the specimens of *C. sycophanta* were dead when received.

Nearly all the material above mentioned was shipped by Miss Ruhl. In 1909, however, a small number of larvæ of *C. sycophanta* was received in boxes of parasitized gipsy moth caterpillars from M. Oberthür and M. Dillon in collections made in France. Lots sent by the former were shipped from Charroux and those by the latter from Hyères.

In 1910 all the specimens were received from Miss Ruhl, and 27

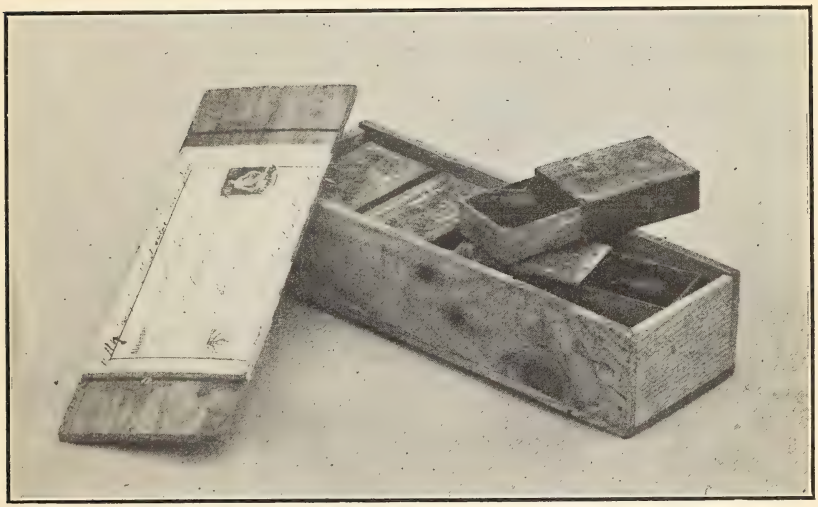


FIG. 4.—Same box as in figure 3, with cover removed to show method of packing Calosoma beetles. Each match box contains a single beetle and a small quantity of wet sphagnum moss. (Original.)

per cent mortality resulted. Table II shows the entire numbers of adult *C. sycophanta*, their condition on receipt, and the percentage of mortality.

TABLE II.—*Number of specimens of Calosoma sycophanta shipped into Massachusetts, 1905 to 1910, number received alive, and percentage of mortality.*

Year.	Number of beetles shipped.	Live specimens received.	Per cent of mortality.
1905	216	1	99.5
1906	821	693	15
1907	2,092	967	54
1908	788	675	14
1909	444	405	9
1910	1,782	1,305	27
Total	6,143	4,046	
Average			34

During the different years this species has been received in greater or less numbers from March to September. The bulk of the shipments usually arrives between June 15 and July 15.

Little difference can be noted in the mortality during this period. When apparent advantage is shown for any particular time of shipment, it is probably due to other causes, such as good packing, rapid transit, or to the fact that the packages were placed in favorable situations on the boats or trains. A record has been kept since 1907 of the mortality of the sexes during shipment, but from this data it appears that the difference is very slight, as practically the same percentage of males and females dies during the season. Nine per cent mortality is as low as can be expected, as some of the shipments are always delayed in delivery, and a certain number of the beetles, especially

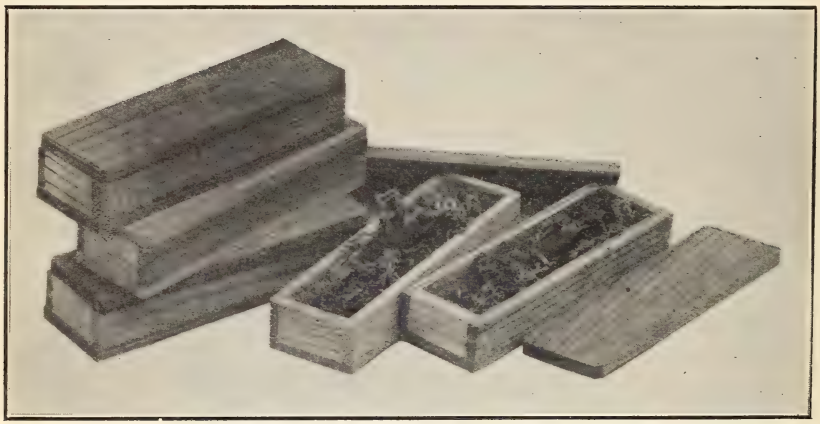


FIG. 5.—Wooden boxes from Japan, showing method of packing Calosoma beetles for shipment. (Original.)

when they are collected in midsummer, would die if allowed to remain in their native home.

The average length of time in transit in 1906 was 10 days, but in a few cases 12 to 14 days elapsed. These figures represent a fair average of the length of time required to ship material from France, Switzerland, or Italy. These beetles can be shipped in a satisfactory manner in cold storage, and this method has been used for Japanese shipments. They were packed separately in wooden boxes (fig. 5) with moist sphagnum moss, and 40 or 50 of these were inclosed in larger wooden boxes, which were placed in the cold room on the boat. On arrival at Vancouver they were forwarded by express and were kept iced until they reached the laboratory.

From this experience it appears that these beetles can be shipped satisfactorily by mail if they are properly packed and are not on the road more than two weeks. The moss in the boxes must be moist; otherwise the percentage of mortality will be large.

EUROPEAN DISTRIBUTION OF CALOSOMA SYCOPHANTA AND HOSTS ATTACKED.

An examination of the European literature gives very little data concerning the distribution of *Calosoma sycophanta*. It is reported as being present throughout France and in Germany, and a few examples have been found in England. There is a single record of this species having been taken in Ireland. Specimens have been received from Italy, and it probably occurs in other European countries.

Réaumur[1] published, in 1736, a general account of the life history of this species and a description of the larva, although he failed to rear the beetle. He states that he has seldom found a nest of the processionary caterpillars that did not contain from 1 to 6 of these larvæ feeding in the midst of their prey. This information has been quoted by many subsequent writers.

Burmeister, in a paper published in 1836,[2] says: "I have often had occasion to observe this insect (*Calosoma sycophanta*), which is not rare in the pine woods in the neighborhood of Berlin, in the larva, as well as in the perfect state, in both of which I have seen it employed in devouring the larvæ of [*Porthetria*] *Liparis dispar* and other moths, which are very common in the vicinity of the capital." Several other reports mention its feeding on gipsy moth caterpillars.

Westwood states that Nicolai has found this species in the forests near Halle, Germany, feeding on *Porthetria dispar* and the pine sawfly, *Lophyrus pini L.*

Valuable information concerning the larvæ of this insect and other species of Calosoma has been published by M. G. de La Pouge, in papers issued by the University of Rennes and in other publications.

PLAN OF WORK AT THE LABORATORY.

On taking charge of the work on predaceous beetles at the Gipsy Moth Parasite Laboratory, plans were made to conduct it along two distinct lines, viz, investigational work and field colonization. As many important facts relating to the life history, food, habits, and the possible influence that each imported species would exert in checking the increase of the gipsy moth and the brown-tail moth were unknown, it was necessary to make careful studies and investigations in the laboratory and field. This work required the utilization of a considerable number of the live insects that were imported. The main object, viz, the liberation of natural enemies in the field, has never been lost sight of, and this feature has been given considerable attention. Field notes have been made concerning the conditions in

[1] Mémoires pour servir a l'Histoire des Insectes, 1736, vol. 2, p. 455, pl. 37, figs. 14–19.
[2] Trans. Ent. Soc. London, vol. 1, p. 235, 1836.

the colonies where beetles were liberated each year, so that their spread and increase could be followed as accurately as possible from year to year.

September 1, 1907, the writer was appointed as expert in charge of breeding experiments in this bureau, and since that time has been engaged in the work during the summers, while the winters have been devoted to other lines of work in Washington. Mr. C. W. Collins, as already stated, has been engaged in the work almost continuously except for a part of the time each winter when other work required his attention. April 1, 1909, he was appointed an expert in this bureau.

During the summer of 1908 Mr. C. W. Stockwell assisted in the rearing work; in 1909 a considerable amount of this work was attended to by Messrs. P. H. Timberlake and S. S. Crossman; and in 1910 Messrs. K. W. Brown, J. J. Culver, and R. G. Smith were similarly engaged. Many of the valuable records that are included are the result of the careful work of these men who, with Mr. Collins, performed most of the tedious work of feeding the various species under observation and kept daily records of the experiments. Mention should also be made of the valuable notes contributed by Messrs. J. V. Schaffner, jr., and E. A. Proctor, who have been engaged in making field observations in the colonies that have been liberated.

The writer is also under obligation to Mr. W. F. Fiske for his general interest and many helpful suggestions; to Mr. F. H. Mosher and various members of the staff of the State foresters' office for suggestions and information concerning field conditions; to Mr. H. R. Gooch, who constructed most of the apparatus used; and to Messrs. H. S. Barber and W. N. Dovener for preparing the illustrations accompanying this report.

The facts brought out in the investigations that have been carried on will be given first, as these have an important bearing on the colonization work which will be described in detail later in the report.

The data which follow refer chiefly to *Calosoma sycophanta*, as this species has been imported in greatest numbers. Others have been given such study as was possible, and it is hoped that more individuals may be received, so that further investigations and liberations can be made.

INVESTIGATIONAL WORK ON CALOSOMA SYCOPHANTA.

In 1906 the investigational work was carried on by Messrs. Titus and Mosher, and some notes and observations were made by Mr. R. L. Webster. During the following summer Mr. Mosher attended to the work until it was taken up by the writer. Beetles were confined in large cages covered with cheesecloth, where they were supplied with caterpillars for food. Several styles of cages were used, and these were located in woodland near the laboratory at North

Saugus, Mass. The average size was 8 feet 6 inches by 11 feet 4 inches, with 8-foot posts. The roof was covered with canvas, and a strip of this material was attached to the sills and extended into the ground to prevent the escape of the insects. It was found that these cages were too large for the purpose of securing detailed data concerning reproduction and the exact amount of food consumed, and the following year they were used only in a limited way.

EQUIPMENT USED FOR REARING PREDACEOUS BEETLES.

Following out the methods used by the writer in 1896–97, when investigating the life history of some of our native species of this genus, an attempt was made to keep this species under observation

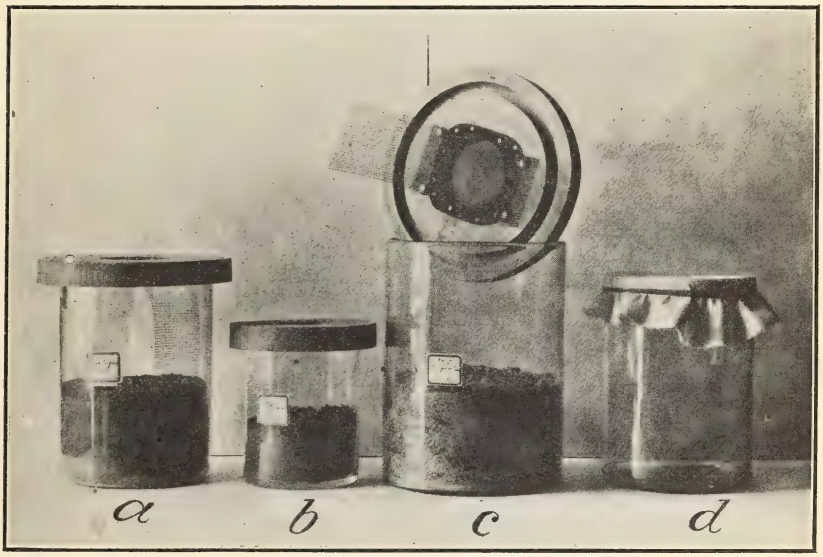


FIG. 6.—Jars for rearing Calosoma beetles: *a*, Large jar with wooden top and "ladder"; *b*, small jar with wooden top; *c*, showing construction of top and "ladder"; *d*, jar with cheesecloth top held in position with rubber band. (Original.)

in glass jars partly filled with earth. The best results were secured by using glass battery jars, which can be obtained from most dealers in glass supplies. The size of the jars selected should be governed by the size of the species to be studied. The best results with *sycophanta* were secured by using jars $8\frac{1}{2}$ inches tall and $6\frac{1}{2}$ inches in diameter, or $7\frac{1}{4}$ inches tall and $5\frac{1}{2}$ inches in diameter, all outside measurements. After the first season a wooden cover was used instead of the usual cheesecloth top. (See fig. 6.) One-inch boards, an inch larger in diameter than the top of the jars, were used for the purpose. These had a 2-inch hole bored in the center which was covered with wire netting. A groove cut near the outer edge of the cover allowed it to fit loosely on the jar. In rearing beetles it has been found of advantage to extend the wire which covers the hole in

the top so that one end of it will reach the earth in the jar. This forms a "ladder" and enables the beetles to climb to the top of the jar and secure the caterpillars which have sought shelter on the underside of the cover.

Jelly glasses partly filled with earth are useful in rearing small larvæ when it is desired to secure accurate records of the length of time in the different stages, the amount of food consumed, and similar details. When the larvæ are nearly full grown it is sometimes necessary to place them in larger jars with more earth or in a tight wire cage which has been partly buried in the earth, as it is necessary for them to have plenty of earth in which to form their pupal cham-

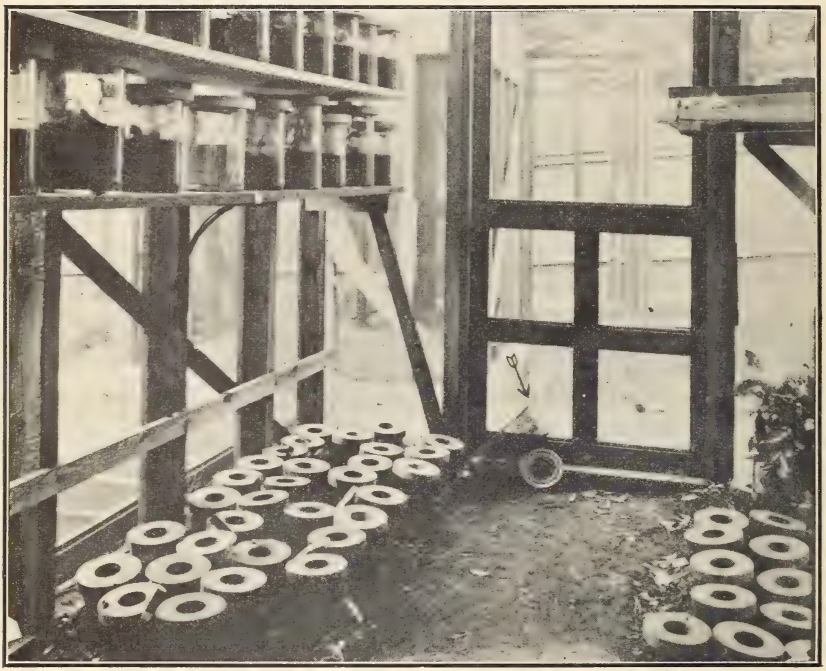


FIG. 7.—Small wire-screen cages, set in ground in insectary, for rearing Calosoma larvæ. The arrow points to an empty cage and cover. (Original.)

bers, and if they are to be reared successfully the ground should not be disturbed.

Cages for rearing Calosoma larvæ have been in use the past three seasons. The bottoms are made of a circular piece of board 4 inches in diameter, having a hole in the center covered with netting. To the circumference of this base is tacked a strip of wire mosquito netting 10 inches wide. It must be cut long enough to lap at the side so that it can be sewed with wire. The selvage of the wire netting should be used for the top of the cage, and care should be taken that the circumferences of the top and the bottom are the same. A cover similar to those used on the glass jars is then placed on the top of the cage. These cages (fig. 7) should be set about 8 inches in the ground,

and larvæ when nearly full grown can be fed in them if desired. The cages should not be disturbed until the following spring, and at that time the beetles which developed will come to the surface of the ground in the cage and can be easily removed.

It is always necessary to provide hibernating quarters for beetles late in the summer, as they pass the winter in the adult state. Boxes of any desirable shape can be used for this purpose. They should be 18 to 24 inches deep, and the bottom should be replaced with galvanized iron wire netting, ¼-inch mesh. (See fig. 8.) They should be set in the ground and filled with earth within 4 to 6 inches of the top. A hinged cover on which the same kind of wire netting is used is a necessity, and the box should be supplied with a lock, so that its contents can not be disturbed by persons of an inquiring turn of mind.

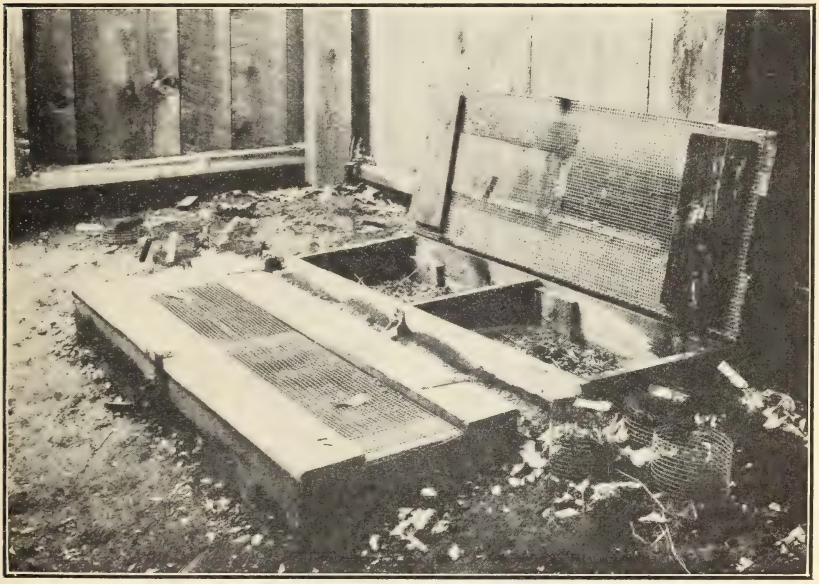


FIG. 8.—Box cages for hibernation of Calosoma beetles. (Original.)

We have also found it desirable to use, for hibernation cages, galvanized iron wire cylinders having a ¼-inch mesh, which are constructed in the same manner as those used for feeding large larvæ. (See figs. 9 and 10.) They are of special value for confining specimens during the winter which have been used for rearing or other special records. Cages similar to the last two types described were used late in the summer of 1909 for feeding large numbers of the larvæ of *sycophanta*, but netting with a fine mesh had to be substituted to prevent the escape of the small larvæ.

It should be stated that the use of these cages had been adopted after several years of experimental work. Many tests of different

kinds of rearing devices have been made and a large number of disappointments has marked the gradual perfection of the methods and devices employed. In the fall of 1907 a considerable number of beetles was placed in hibernating cages made of galvanized iron bent into the form of cylinders which were sunk in the ground about 20 inches, allowing 4 inches to protrude. Each end was covered with mosquito netting and these appeared to furnish excellent quarters for wintering beetles. Experience showed that the earth in these cages became so wet and later so compact that practically all of the beetles died, some of them being crushed in their pupal chambers.

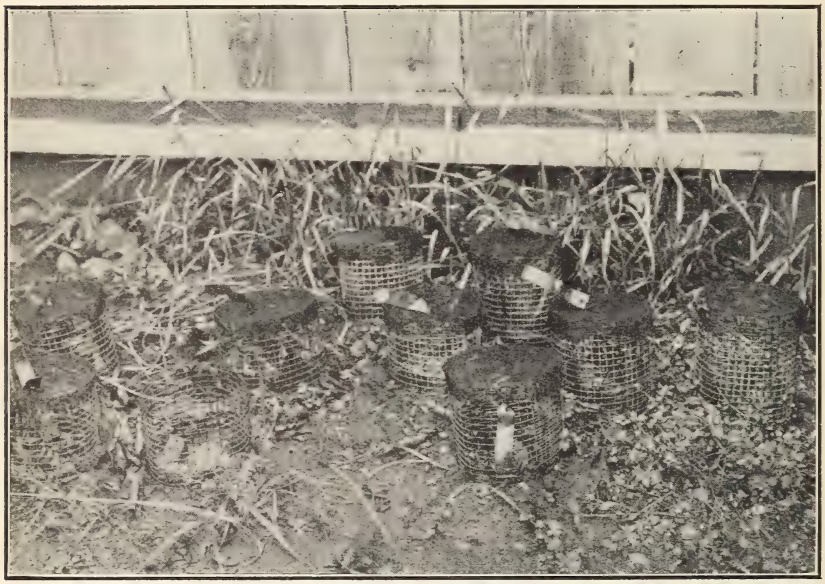


FIG. 9.—Galvanized-iron wire cages used for wintering pairs of Calosoma beetles. (Original.)

Fortunately all of the rearing stock of the season was not placed in such cages so that the work the following spring did not have to be discontinued on account of lack of living specimens.

OUTDOOR INSECTARY FOR REARING CALOSOMA BEETLES.

In the spring of 1908, after moving to the present laboratory at Melrose Highlands, it seemed desirable to build a temporary insectary for rearing beetles during the summer. Accordingly a house 11 feet 4 inches by 5 feet 10 inches with posts 5 feet 6 inches in height was built in the yard at the rear of the laboratory. (See fig. 11.) The lumber used was 2 by 3 studding, and the sides were walled in with mosquito wire. The rafters extended about 6 inches beyond the plates and the roof was covered with canvas which was held in place

with furring. The sills of this house rested directly on the ground and canvas curtains were provided on the south and west sides to shut off the direct sunlight during hot weather. Shelves were placed along the inside walls of the house and the earth on each side of a central walk was used for ground rearing cages.

It was found that the heat was too great in the top of the house during midsummer, and the following spring, when it was necessary to have more space for beetle rearing, another house (Pl. II, *A*) was built. Cement walls 4 inches wide were used for a foundation and the posts were 8 feet in height. Several partitions were built in one side of the house which provided special breeding compartments (see Pl. III); otherwise the construction was very similar to that of the building of the previous year. Little difficulty from excessive heat was experienced in this house and this form of temporary outdoor insectary has been found admirably suited to this line of work. In the winter the roof is removed and the wire can be taken off the sides if desired, so as to leave absolutely natural conditions for the hibernating insects in the cages.

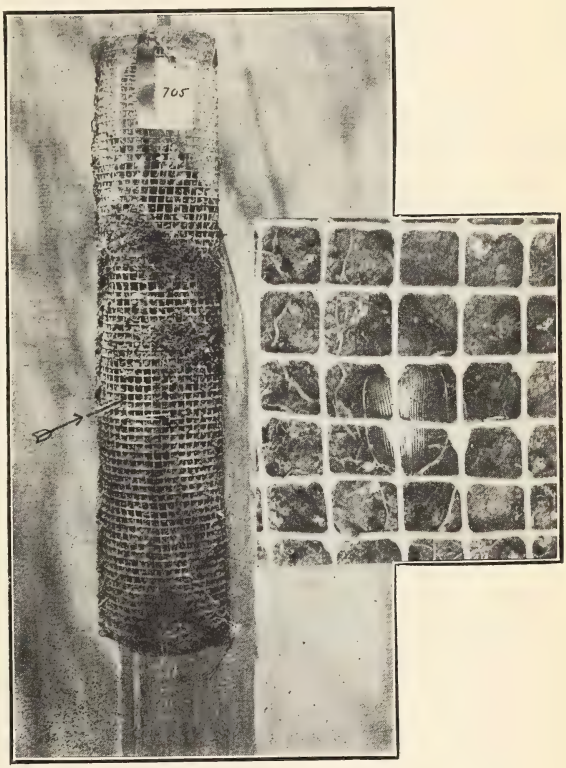


FIG. 10.—One of the cages shown in figure 9 that has been removed from the earth. Arrow shows the cavity where a Calosoma beetle hibernated; enlargement shows this beetle in the cage. (Original.)

In the spring of 1910 another house (Pl. II, *B*) was built very similar to the one constructed the previous year. It covered 12 by 15 feet on the ground and was fitted with shelves on all sides and a large table in the center. (See Pl. IV.) The building was very commodious and convenient for work and was constructed for less than $150.

METHODS OF REARING PREDACEOUS BEETLES.

Late in July, 1907, several beetles which were received in shipments from Europe were placed in jars with earth, one pair in each, and fed with caterpillars daily until they refused food, and entered the ground for hibernation. The earth was examined for eggs at the time new food was added, but only one pair reproduced. It was necessary to remove carefully the caterpillars that had been killed by the beetles each day, to keep the jars from becoming foul and to prevent the development of certain mites (*Tyroglyphus* sp.) which feed on decomposing animal matter, after which they attack the beetles and their larvæ, causing serious injury and sometimes death.

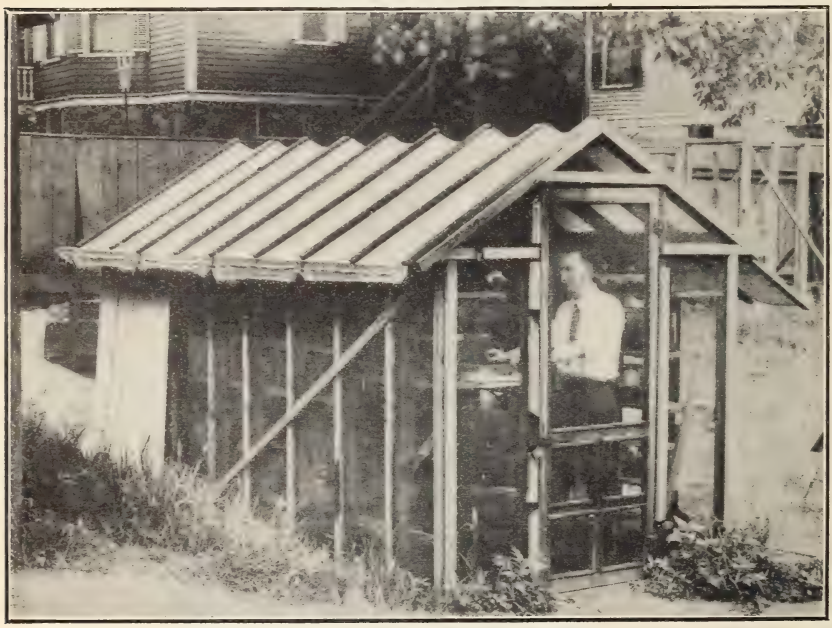
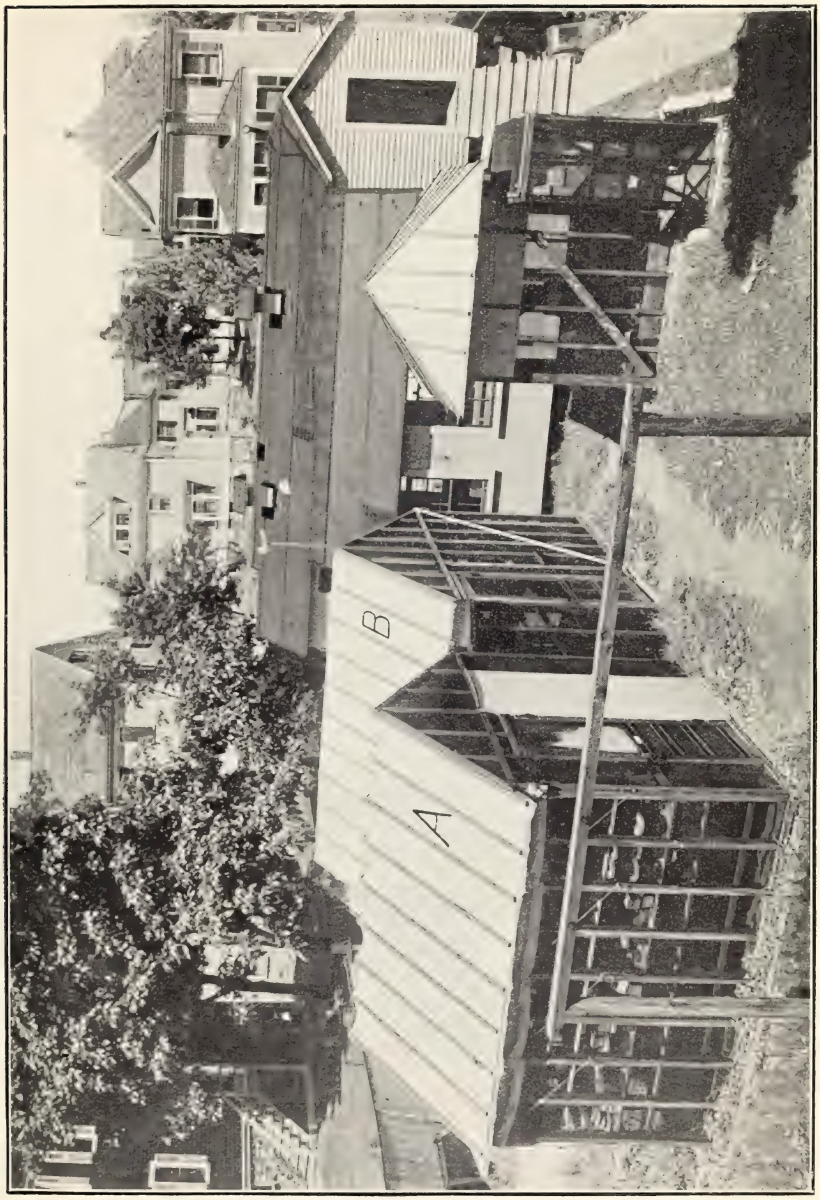


FIG. 11.—Outdoor insectary used for rearing Calosoma beetles. (Original.)

When eggs were found the beetles were transferred to another jar, which was given the same number as the one originally assigned, the first jar being kept under observation for larvæ.

The number of larvæ that hatch is usually taken as the index of the number of eggs deposited. It is impracticable to remove the eggs from the earth to make accurate counts, as they are easily injured in handling.

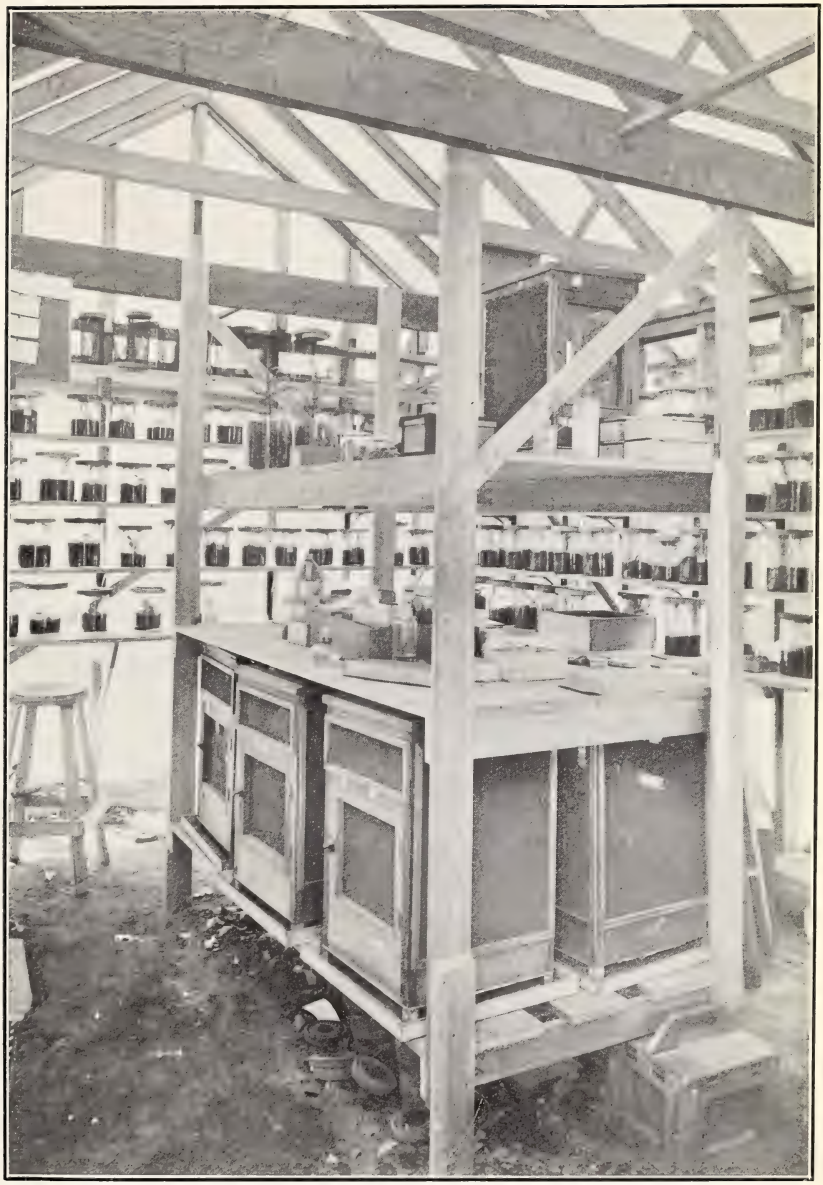
Several of the larvæ that hatched in August, 1907, were fed in separate jelly glasses containing a small quantity of earth, and later they were transferred to cages out of doors, to enter the pupal stage. A few pupated in earth in large jars, and some of these were placed in



PRESENT OUT-DOOR INSECTARIES FOR REARING CALOSOMA BEETLES.

A was built in 1909; *B* was built in 1910. (Original.)

INTERIOR VIEW OF INSECTARY "*A*," SHOWN IN PLATE II. (ORIGINAL.)



INTERIOR VIEW OF INSECTARY "*B*," SHOWN IN PLATE II. (ORIGINAL.)

a cellar during the winter, and young beetles were recovered in the spring. Other pupæ were removed from the jars and placed in out-of-doors cages. It was necessary to construct an artificial chamber in the earth in which to place each pupa, and this was done successfully in a few cases. A better plan is to allow the larva to make its pupal cell and not to permit the earth to be disturbed until the following spring.

The method above described of rearing these beetles was so satisfactory that in the spring of 1908 an attempt was made to rear larvæ for liberation in field colonies. By holding some of the shipments of beetles that arrived late in the summer of 1907 and placing them in large hibernation cages it was possible to have a stock of breeders ready for use as soon as desired in the spring.

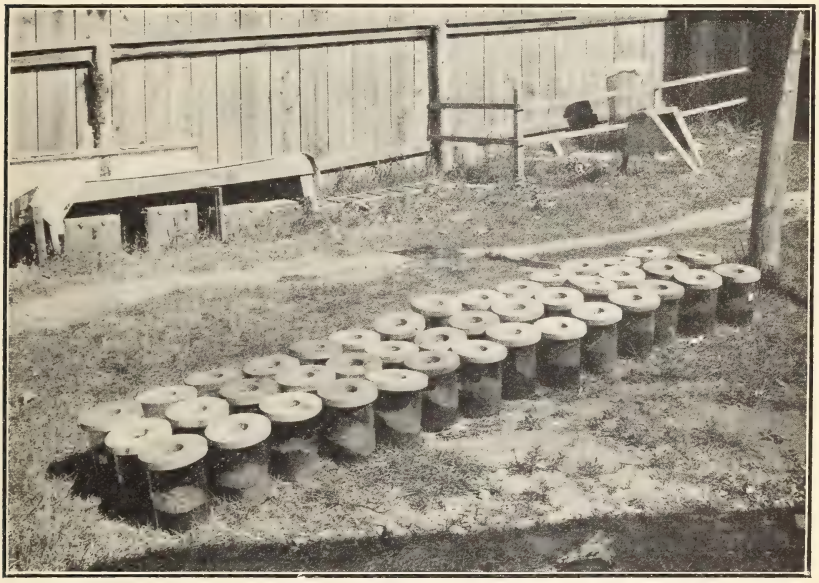


FIG. 12.—Jars of earth containing eggs of *Calosoma sycophanta*. They have been placed in the sun to hasten hatching. (Original.)

The result of the work for the year was the rearing for colonization of 2,300 larvæ. During the following year this line of work was continued and 6,100 additional larvæ were placed in field colonies, and in 1910 6,380 were reared and liberated. When larvæ are being reared for liberation in field colonies it is desirable to hasten their development as much as possible. They are given an abundance of food and the jars containing eggs (fig. 12) are placed in the sun on cool days to accelerate hatching. The method of liberating larval colonies enables the species to become established over a much wider range and also gives it a better chance of surviving, owing to the varying conditions and locations in which it can be placed.

The beetles can be reared with fair success after some experience has been obtained in properly handling them. The food supply is one of the problems that causes considerable difficulty, especially early in the spring and late in the summer. Before gipsy moth larvæ are large enough to satisfy the ravenous appetites of the beetles, tent caterpillars have been used when it was possible to find them in sufficient numbers, while after the middle of July larvæ of the white-marked tussock moth, fall webworm, or any other caterpillars that could be collected have been used.

Each season the continuous services of one man have been required to collect caterpillars for beetle food, and at some times each year he has usually found it impossible to bring to the laboratory enough specimens to supply the demand. The amount of food consumed by beetles or larvæ is noted daily when the jars are examined, so that the feeding and rearing records can be observed at one time.

Owing to the carnivorous habits of the larvæ it is usually necessary to isolate them. This is especially true if detailed records are to be kept, or if they have become nearly full-grown. Hot weather stimulates their activity and appetite, and it is seldom possible to keep several large larvæ in the same jar during hot weather unless an abundance of food is supplied, and even then some of them usually succumb to the attacks of their comrades. The small larvæ do not attack each other so ferociously, but when some are practically helpless at the time of molting they fall an easy prey to the others. During the summer of 1909 and 1910, when large numbers were being reared for field colonies, it was impossible to isolate each individual, and as soon as hatching took place 10 to 15 were placed in a large battery jar containing earth and an abundance of food. If they were not allowed to remain more than three or four days before removal, the mortality was relatively low. Later in the season, after all the gipsy moth larvæ and pupæ had transformed in the field, as many as 200 larvæ were reared in box cages (Pl. V) having a surface area of 2 by $3\frac{1}{2}$ feet. The weather was cooler at that time, and although a considerable number was killed, it did not render this method of rearing impracticable for use in late summer.

INVESTIGATION OF THE LIFE HISTORY OF CALOSOMA SYCOPHANTA.

One of the factors which renders this investigation somewhat difficult is the length of life of the adults. Only a small amount of data is available, because it is necessary to rear beetles in the laboratory in order to get the initial information. Many species of insects die as soon as the females have deposited eggs, or the males have fertilized the opposite sex, but this species, as well as others in the same genus, have an entirely different habit of life.

One female beetle received from Europe in July, 1907, was kept under observation at the laboratory for two years, so that the length of life may normally be considerably longer.

Nearly one-half of the beetles reared from eggs in 1907 that emerged from the earth in the spring of 1908 survived the summers of 1908 and 1909, and went into hibernation in the fall. This serves to illustrate the prolonged period throughout which accurate records must be kept, and the care with which the work must be conducted in order to secure correct data.

During the summer of 1910 measurements were made of 12 freshly-laid eggs and the same number of larvæ on entering each stage, and these notes are included in the descriptions of stages which follow.

THE EGG.

Twelve fresh eggs gave the following average measurements: Length, 5.2 mm., width, 2.4 mm. They are somewhat elliptical in form, with a slight taper toward one end. The color is white, with a faint yellowish tinge. They vary somewhat in size and form and before hatching often become somewhat kidney-shaped.

The time spent in the egg stage is from 3 to 10 days, and depends largely on the temperature. Careful observations on 2,000 eggs that were laid from May 15 to August 18, 1908, are summarized as follows:

TABLE III.—*Duration of the egg stage in Calosoma sycophanta.*

Egg stage.	Number of eggs in—				
	May.	June.	July.	August.	Total.
3 days			75	13	88
4 days		78	444	7	529
5 days		605	451	3	1,059
6 days	23	164	36	3	226
7 days	39	32			71
8 days	9	8			17
9 days	6				6
10 days	1	3			4

Average time in egg stage:	Days.
May	7
June	5.2
July	4.4
August	4

The eggs recorded as hatching in May were secured from females that were taken from hibernation in March, April, and May and fed in the laboratory. Oviposition seldom takes place under natural conditions in the month of May.

The average length of time spent in the egg stage, based on the hatching each month during the summer, was: May, 7 days; June, 5.2 days; July, 4.4 days; and August, 4 days.

The table also shows that 4.4 per cent of the eggs laid in 1908 hatched in 3 days, 26.4 per cent in 4, 53 per cent in 5, 11.3 per cent

in 6, 3.6 per cent in 7, 0.8 per cent in 8, 0.3 per cent in 9, and 0.2 per cent in 10 days.

That temperature has a predominant influence on the hatching of the eggs can not be doubted, and in this connection the following

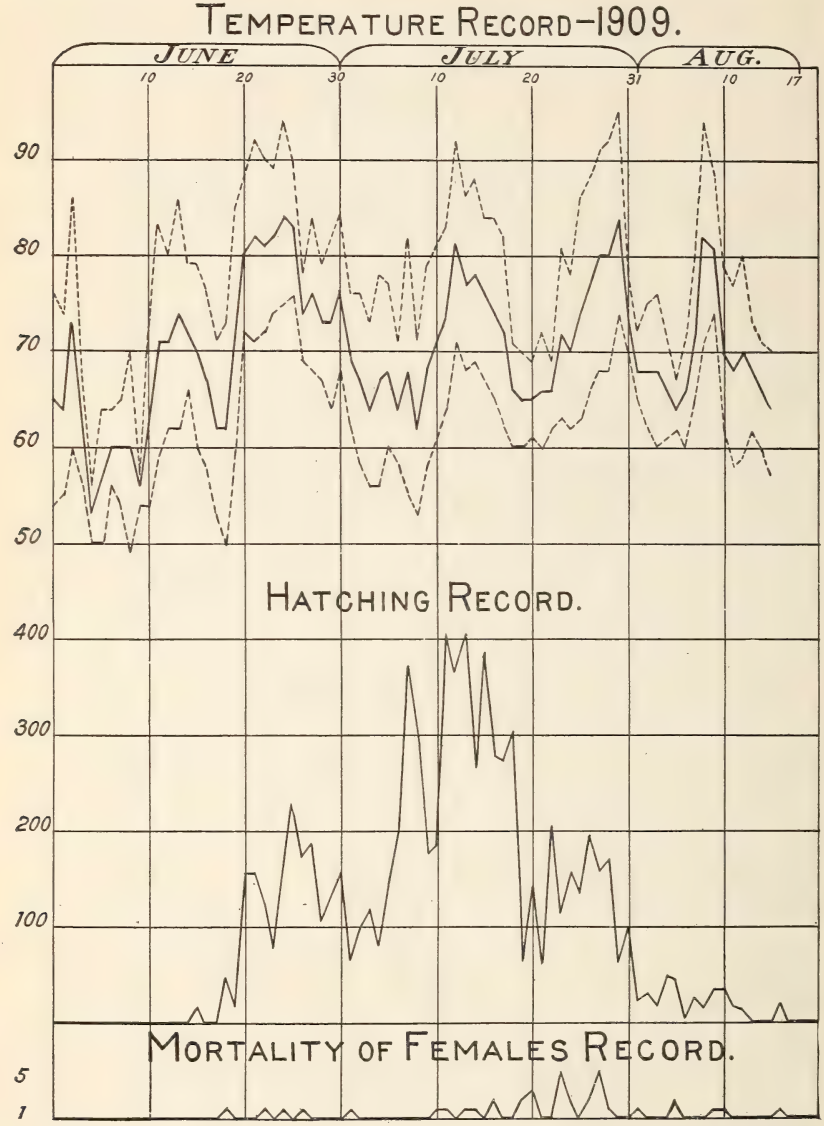
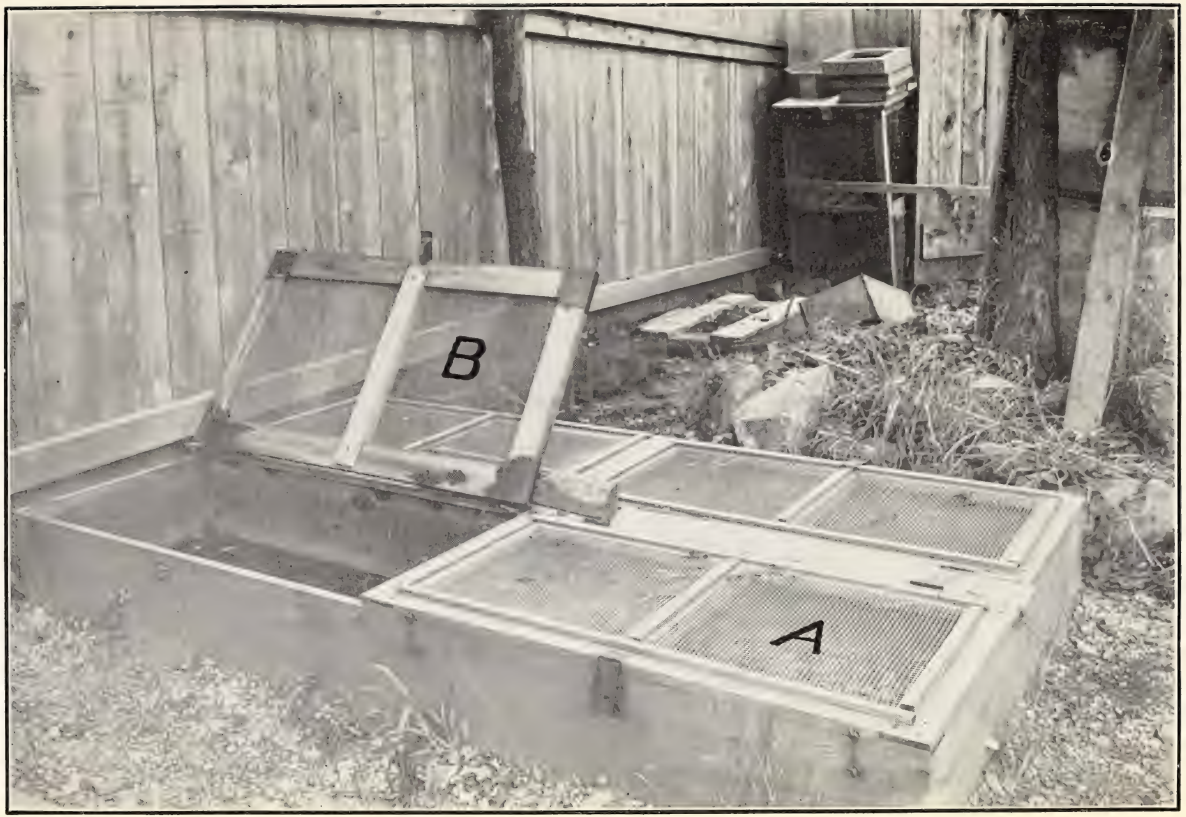


FIG. 13.—Diagram showing temperature record during the summer of 1909, the total egg-laying record, and the mortality of female Calosoma beetles for the same period. (Original.)

data, secured from the United States Weather Bureau at Boston, are of special interest.

The accompanying diagram (fig. 13) shows that during each period of high temperature there was an increase in the number of



BOX CAGES USED FOR REARING CALOSOMA LARVÆ LATE IN THE SUMMER.

B, cover with fine-mesh screen, used in summer: *A*, showing coarse-mesh screen top, used after the larvæ have gone into the ground to transform and hibernate. (Original.)

eggs, as is indicated a few days later by the hatching record. This held true until the food supply began to fail late in July.

It will also be noted that the greatest mortality of females occurred about the last of July and indicates the relation between temperature, egg laying, food supply, and mortality.

Notes on Hatching.

As the eggs are deposited in the earth by the female Calosoma beetles, it is difficult to secure exact data on the superficial changes that take place. The following note is of interest.

On August 2, 1907, two eggs laid that day were placed in earth in a jar, to observe the changes that take place previous to hatching. They were placed 1 inch below the surface of the earth and against the side of the glass, so that they could be easily seen. August 6, they were somewhat darker in color and had become slightly kidney-shaped. At 8 a. m., August 7, a larva had hatched from one egg and the other was dark gray in color, the segmentation of the body being plainly visible. At 2 p. m. the egg had hatched and the larva had moved away from the cavity. At 8 a. m., August 8, the larva which hatched first had made a tunnel to the surface of the ground, but had returned and was occupying the egg cavity. The other larva was not in sight. At 2 p. m. both larvæ were crawling on the earth in the jar in search of food.

Usually the eggs do not begin to assume a darker color until about 24 hours before hatching, although the change in outline and indications of segmentation are apparent before that time.

Infertile eggs sometimes become kidney-shaped, but usually the outline is more or less irregular and segmentation of the contents has never been observed. Such eggs usually contract to some extent in a few days. In most cases they become dark in color and gradually shrivel up and disappear in the earth.

To illustrate the care which must be taken in transferring the eggs of this insect, if it is necessary to do so, the following case is cited.

On July 23, 1908, a Riley cage, having a galvanized iron base containing earth, was examined for eggs. It contained a supply of Calosoma beetles which had been received from Europe some time previous. The insects were transferred to another cage and the earth was found to contain 253 eggs, which were placed in jars to observe hatching. One hundred and eighty-five larvæ developed from these eggs, or 73 per cent of the total number. Probably some of them were infertile, but allowing that this was the case, at least 20 per cent of the eggs must have been injured during the transfer.

Effect of Cold on Eggs.

As eggs are sometimes laid in August, it seemed desirable to test in a limited way their resistance to cold. Accordingly, on August 8, 1907, a jar containing a single egg in a quantity of earth was placed in cold storage, where the temperature was maintained at 26° F. This jar was packed in a box with several others, a small quantity of excelsior being used between them to prevent breakage and also to permit the contents to cool slowly. On August 22, two weeks later, the jar was removed to the laboratory, but the egg in question did not hatch.

Another jar, containing earth and two eggs, was placed in cold storage on the same date (August 8), but it was not removed until June 4, 1908, nearly 10 months later. An examination showed that the earth was very dry and the eggs had shriveled up.

Although few eggs were used in these experiments, the results seem to show that they will not hatch after being subjected to freezing temperatures.

THE LARVA.

The larvæ on hatching are nearly white, although slightly darker than the eggs. They remain in the chamber in which the egg reposed, and gradually grow darker until they become jet-black. About this time, if the weather is warm, they become active and make their way to the surface of the ground in search of food. The following description is made from a comparison of several larvæ after they had become fully colored and fed slightly. They molt twice and a brief description of each stage is given.

First-Stage Larva.

Average length of 12 newly-hatched specimens, from base of mandibles to posterior end of last abdominal segment (not including anal proleg or caudal appendages), 9.3 mm. Average width at mesothoracic segment 2 mm.

The anal proleg is usually 1 mm. in length and the caudal appendages are about twice as long and taper gradually to the tips.

Color jet-black above; legs, antennæ, and mouth parts dark mahogany brown. If placed under a lens the body appears very dark brown, and the legs and mouth parts are of a somewhat lighter shade. Joints of antennæ, palpi, legs, and underside of body of a pearly color, except chitinous markings, which are jet-black. General outline of body fusiform. Antennæ longer than mandibles; maxillary palpi nearly as long as antennæ, tapering to tip of last joint; labial palpi stout, last segment cylindrical, truncate; prothorax wider than long. Second abdominal segment as wide as the first, body tapering quite abruptly beyond the fifth abdominal segment. Body provided with rows of lateral and ventral spines. Legs spiny. Caudal appendages bearing a few spines.

Second-Stage Larva.

Average length 15.5 mm. Average width 3.4 mm. Much stouter than first-stage larva. Body shining jet-black, mandibles and legs mahogany-brown, mouth parts lighter, nearly honey-yellow, dorsum of last abdominal segment and tip of proleg light

brown. Caudal appendages relatively shorter than in preceding stage, each provided dorsally with a stout but short protuberance on its inner third, which bears a stout bristle.

Third-Stage Larva.

More robust than in previous stage. Average length 25.8 mm. Average width 5.7 mm. Body shining black in color, mandibles, legs, mouth parts, antennæ, and lateral and ventral abdominal markings dark brown. Prothorax much wider than long, wider behind. Dorsum of last abdominal segment and anal proleg chestnut-brown. Dorsal abdominal plates nearly truncate behind, lateral margins of each raised and thickened. These margins more prominent on the last three segments. On the penultimate segment, each dorso-lateral margin forms a stout, blunt, overhanging fold, while on the last segment each margin is drawn out into a stout tooth, pointing backward.

Median dorsal line prominent on all segments except the last. Caudal appendages short, quite erect, with a large, stout dorsal tooth, and a small lateral tooth, both of which are provided with spines.

The Process of Molting.

The larvæ are active and feed voraciously; during this time their bodies are greatly distended and the white portions of the integument render the insect quite conspicuous. Just before the molting begins they become sluggish and do not move about unless disturbed. The body shortens and becomes thicker than normal. By moving the head and posterior end of the body downward and toward each other at regular intervals the integument is ruptured along the dorsal line of all the thoracic segments. The head, mouth parts, and legs are gradually withdrawn and a pure white larva crawls from the old skin. Usually the sutures on the top of the head are broken as the larva makes its escape. The molting process requires but a few hours, and this is fortunate, as the larva is practically helpless while the transformation is being accomplished.

In nature the larvæ often molt under litter on the ground, but when they are feeding on caterpillars on the trees molting takes place in holes or cavities in the trees, among masses of gipsy moth pupæ, or even in crevices of the bark. It is probably true that many of the larvæ pass through the two molts without descending to the ground.

Length of Time in Larval Stages.

The duration of time between the molts is influenced greatly by high temperatures and food supply. In the spring of 1908, careful records were kept of a number of larvæ which hatched from eggs deposited by beetles that were removed from hibernation in March and early April. One of the objects of the experiment was to determine the length of time required by larvæ that hatched early in spring to pass through their transformations, and further, to determine the possibility of such larvæ developing a brood of beetles which would become active and reproduce during the summer. A considerable

number of individuals in the experiment died owing to a scarcity of food and other causes, but the following nine records give the length of time which was spent in each larval stage and this may be considered as approximately correct for larvæ that hatch early in the season when the weather is cool and the food supply is somewhat restricted.

From the foregoing experiments data were secured regarding the length of time in each larval stage.

TABLE IV.—*Record of time passed in different stages by larvæ of Calosoma sycophanta hatched from eggs laid by beetles taken out of hibernation in March and April.*

No.	Date hatched.	First-stage larvæ.	Second-stage larvæ.	Third stage (until finished feeding).
	1908.	*Days.*	*Days.*	*Days.*
765A[1]	May 23	6	5	18
765A[3]	May 24	8	2	19
765A[6]	May 25	7	4	15
765A[7]	May 26	6	9	13
765A[9]	May 27	6	8	15
765A[11]	do	5	7	16
765A[14]	do	5	8	14
765A[15]	May 28	4	8	14
765A[2]	do	4	8	15

Average length of time in each stage:	Days.
First larval stage	5½
Second larval stage	6½
Third or feeding stage	14½
Total time larvæ fed	26½

In order to check up this experiment and to determine the difference in time required for larvæ to develop during hot summer weather when food is abundant, another set of experiments was carried on with larvæ that hatched on June 20 and the results are tabulated as follows:

TABLE V.—*Length of time passed in different stages by larvæ of Calosoma sycophanta developed from eggs laid by beetles that emerged normally.*

No.	Date hatched.	First-stage larvæ.	Second-stage larvæ.	Third stage (until finished feeding).
	1908.	*Days.*	*Days.*	*Days.*
771D	June 20	2	3	9
771E	do	2	3	9
771F	do	2	3	9
771G	do	2	3	7
771H	do	2	3	9
771I	do	2	3	9
771J	do	2	3	9
771K	do	3	2	9
771L	do	2	3	9
771M	do	2	3	9
771O	do	2	3	9
771Q	do	2	3	9

Average length of life in feeding stages:	Days.
First larval stage	2
Second larval stage	3
Third larval stage	9
Total	14

An examination of this table shows that larvæ hatching late in June transformed much more rapidly than those noted in Table IV, the difference in the total average length of time being 12½ days. Similar records based on a few experiments have been secured from larvæ that hatched at the laboratory late in July or during the first few days in August. The length of time spent in the larval stages was longer than the time required for the larvæ hatching in June. This is partly due to the difficulty of furnishing an ample food supply in August.

Time of Appearance of the Larva.

The date of the first appearance of the larva of this species in the field, of course, differs from year to year, depending on the season, and in colonies that have been liberated larvæ are seldom found as soon as the first ones hatch and begin feeding. The records of this investigation are rather fragmentary because of the relatively small number of adults that have been liberated in field colonies since the work began, and owing to the difficulty of making frequent examinations of any given colony and searching thoroughly enough to find the small larvæ. The earliest field records, however, are as follows: 1907, July 17; 1908, June 29; 1909, July 7; 1910, June 27. It should be stated that the first larvæ found in 1907 were nearly full grown, which explains partially the reason for their being found so late in July, although the season was not so early as that of the two following years. The latest records which we have of finding larvæ in the field are as follows: 1907, August 7; 1908, July 8; 1909, August 3; 1910, August 2. In the laboratory, where food was more abundant in early June and during the month of August than in the field, it has been possible to rear larvæ over a longer period of time. Aside from the food problem it has been possible to control to some extent temperature and moisture conditions, so that the time during which feeding experiments have been carried on has been prolonged.

Habits of the Larva.

Larvæ of this species secure food by searching for the caterpillars and pupæ of various lepidopterous insects. Undoubtedly some of those attacked are found on the surface of the ground or beneath leaves or litter, where they have sought shelter either for protection or pupation. The larvæ of this species, however, in addition to feeding in such situations are able to climb trees and devour their prey upon the trunks or branches. To this extent they may be considered arboreal in habit, although they are seldom found in any great quantities on trees which have smooth bark, as it is quite necessary for them to travel over uneven surfaces in order to secure a sure

footing. Not only do the larvæ secure a part of their prey in the trees, but they molt in crevices of the trunks and branches to a considerable extent. This habit is so general that it has been possible to determine quite accurately the dispersion of the species by examining trees for molted skins outside the areas where colonies have been liberated. This work can be done even after all larvæ have entered the ground for pupation, so that the time when satisfactory investigations can be made extends over the greater part of the summer. Trees in the gipsy moth infested sections which have been burlapped are favorite resorts for the Calosoma larvæ, as they find plenty of food available and are protected in a large measure from enemies that might destroy them. (See Pl. VI.) To determine the distance that larvæ of this species will climb, the following observation was made at West Gloucester, Mass. July 30, 1908, a number of larvæ was liberated in woodland and several were placed at the base of a red oak tree about 10 inches in diameter. Two of these larvæ immediately commenced climbing the tree. One ascended to a distance of about 10 feet and as no food was present it retraced its steps and returned safely to the ground. The other continued its journey up the tree. At a distance of 15 feet from the ground the bark became very smooth and offered little opportunity for the insect to obtain a safe footing. It continued to climb, however, until it reached a point about 25 feet from the ground, where it lost its hold on the bark and fell. There is no doubt that these larvæ often climb nearly to the tops of rough-barked trees, particularly white oak, in search of food. Several cases have been noted where molted skins were found at least 20 feet from the ground, and they have been observed in masses of pupæ on the underside of branches near the tree trunk. The climbing habit of the larvæ is of great importance, as it increases the opportunity for the development and usefulness of the species.

Distance Traveled by the Larva.

Inasmuch as young larvæ of this species must be able to find suitable food in order to develop, the question of their ability to travel is one of great importance. It seemed desirable to test this matter and plans were made and apparatus constructed for the purpose. A young larva was taken which had just hatched, and a record kept of its travels until it died, no moisture or food being supplied throughout the experiment. In order to secure this record a small table 3 feet 8 inches long by 2 feet wide was equipped with spools at each end near the top so that a roll of paper could be reeled across the top of the table by turning the spools. (See fig. 14.) Beneath this paper was placed a piece of stiff wrapping paper which extended beyond the sides

of the paper connected with the reels, and the edges were bent upward in such a manner as to prevent the escape of the larva from the sides of the table. The paper on the reels consisted of ordinary wrapping paper 18 inches in width. The larva was placed in the center of the table and the record of its travels was made with a lead pencil. The experiment was begun at 8.30 a. m., June 18, 1910, and was conducted by Mr. C. W. Collins, with the assistance from time to time of various

FIG. 14.—Method of securing data on the distance traveled by larvæ of *Calosoma sycophanta*. (Original.)

members of the laboratory force. It was necessary to carry on this experiment continuously until the larva died, and as it remained active for 72 hours shifts of men were used so that there was no break in the record. The larva traveled far more rapidly than was expected and it became necessary from time to time to substitute a fresh roll of paper in place of the one containing the record. In all 11 rolls were used and careful measurements indicate that during its life the larva

traveled 9,058 feet or 1.71 miles. (See fig. 15.) It might be of interest to state that the insect was active the greater part of the time, and that the greatest speed for a 4½-hour period was 4.9 feet per minute, and that during the first 24 hours the average rate of travel was 3.69 feet per minute. After the second 24 hours the rate of travel decreased gradually, and during the last 12 hours the larva spent considerable time at rest. During the course of the experiment the larva lost about 0.11 grains, or a little more than one-third of its original weight. This experiment shows the remarkable vitality possessed by these larvæ, and indicates that under any conditions they would be able to survive for several days and travel a considerable distance before succumbing from the effects of hunger. The conditions under which the test was conducted were, of course, abnormal, and it is not presumed that a larva of this species would travel as great a distance as

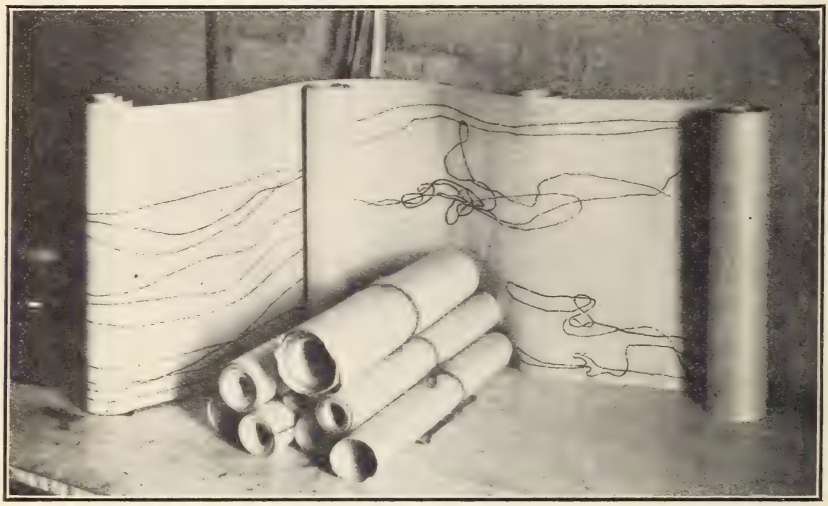


FIG. 15.—Roll of paper showing record of distance traveled by larva of *Calosoma sycophanta*. (Original.)

that indicated in the record. It should be said, however, that in certain respects the test was unfavorable for the larva, owing to the fact that no moisture whatever was supplied and that it traveled on a dry surface and at a temperature which made rapid evaporation possible.

FEEDING HABITS OF THE LARVA.

The larvæ of this species appear to feed both by day and night, but their activity in this direction is greatly stimulated if the weather is hot. As a rule the caterpillars are attacked from the side or in the middle of the back, and if they are hairy specimens the favorite place seems to be between the segments where the larvæ can more readily pierce the integument with their sharp mandibles. Newly hatched larvæ of *sycophanta* are able successfully to combat equally well all

LARVÆ OF CALOSOMA SYCOPHANTA FEEDING ON GIPSY MOTH CATERPILLARS UNDER BURLAP.

Photograph taken at Pine Banks Park, Malden, Mass., 1910. (Original.)

caterpillars regardless of size. After the body wall of a caterpillar has beeen cut, the Calosoma larvæ feed upon the juices and apparently devour a large amount of the fat body of their prey. The entire internal tissues of the caterpillar are seldom eaten, and many specimens are injured to such an extent that they eventually die, and thus more caterpillars are prevented from transforming than are actually eaten. The pupæ of Lepidoptera, especially those which are destitute of a cocoon, suffer greatly from the inroads of the larvæ of this insect. In fact, so far as the gipsy moth is concerned, it is probable that the destruction of the pupæ is fully as great as that of the larvæ. Of course the pupæ are practically unprotected and are in a helpless condition, so that they fall an easy prey to the hungry beetle larvæ. Usually the larva forces its mandibles through the gipsy moth pupa, between the segments. The hole is greatly enlarged and the contents of the pupal case are removed before the larva passes on to another pupa. The entrance holes made by the Calosoma larva in the pupa of the gipsy moth are characteristic. (See Pl. VII.) They are always irregular in outline and sometimes extend nearly the entire length of the pupal case. It is very easy to distinguish these holes from others made by parasites. Fresh gipsy moth pupæ are possibly more subject to attack than those from which the adults are more nearly ready to emerge, but there seems to be only a relatively small amount of discrimination used by the larva in selecting its victim. Where pupæ are massed on the trunks of trees under branches or in any sheltered position an extremely favorable opportunity is presented for the larvæ of this beetle to operate. In fact, in colonies where the beetles are numerous it is not uncommon to find one or more of the larvæ in every large mass of pupæ examined. (See fig. 16.) Usually it is necessary to disturb the pupæ, otherwise the beetle larva will be overlooked as it secretes itself beneath the silk and old pupal cases which form the mass and feeds from beneath on the living pupæ. Examinations that have been made during the last two years directly in and throughout the territories surrounding many of the beetle colonies which have been liberated in the field, have revealed the presence of large numbers of pupal cases that have been destroyed by the beetle larvæ, although it is seldom possible to find anything like the number of molted skins of the beetle larvæ that might be expected from the number of gipsy moth pupæ that have been destroyed. In field colonies, the larvæ of *sycophanta* have been found attacking and killing adult females of the gipsy moth. In one case the end of the abdomen of the female was pierced and in spite of the large amount of fine hairs with which the insect is provided and which must be distasteful to such a small predator as a beetle larva, the internal portion of the abdomen including most of the eggs was devoured and of course the death of the moth resulted.

Food of the Larva.

The larvæ of *Calosoma sycophanta* feed chiefly on lepidopterous caterpillars and pupæ. It may be that coleopterous or other larvæ or pupæ which live on or near the surface of the ground are destroyed, but we have no definite data bearing on this matter. Apparently the larvæ prefer large caterpillars or pupæ which have a considerable amount of fatty matter in the body cavity. This makes gipsy moth larvæ and pupæ particularly suitable as food for these predaceous larvæ. In rearing work at the laboratory only a few species have been furnished and these have been selected on account of their abundance and the ease with which they could be collected. Forest and American tent caterpillars (*Malacosoma disstria* Hbn. and *M. americana* Fab.), gipsy moth larvæ (*Porthetria dispar* L.), brown-tail moth larvæ (*Euproctis chrysorrhœa* L.), and fall webworms (*Hyphantria textor* Harr.) have been used to the greatest extent and all of these species except the last mentioned have been attacked with equal avidity. It is probable that fall webworm larvæ, on account of their small size, the dense hairy covering of the body, and the character of their internal contents are not a preferred host of this species, and we have observed that beetle larvæ thrive better on more robust specimens.

Fig. 16.—Larva of *Calosoma sycophanta* feeding on gipsy moth pupæ on trunk of tree, North Saugus, Mass., July, 1907. (Original.)

Aside from the species already mentioned, *sycophanta* has fed freely in captivity on all species of caterpillars offered, among which may be mentioned: *Papilio polyxenes* Fab., *Callosamia promethea* Dru., *Estigmene acræa* Dru., *Halisidota caryæ* Harr., *Alypia octomaculata* Fab., *Catocala* sp., *Heterocampa* sp., *Heterocompa guttivitta* Walk., *Gluphisia septentrionalis* Walk., and *Hemerocampa leucostigma* S. and A.

Experiments in Feeding Larvæ.

AMOUNT OF FOOD REQUIRED.

During the summer of 1908 two series of experiments were conducted for the purpose of determining the number of caterpillars which would be eaten by larvæ of *Calosoma sycophanta* from the time of hatching until ready for pupation. Each larva was placed in a jelly glass with a small amount of earth, and caterpillars were supplied daily and a record kept of the number eaten. The first set was begun May 23, with a few larvæ, and records were kept of numerous others which hatched from that time until May 28. The eggs from which these hatched were deposited by beetles that were removed from hibernation during March and April. Sixteen larvæ were fed in this experiment and the amounts which were eaten will be found in Table VI.

Table VI.—*Food eaten by larvæ of Calosoma sycophanta.*

Date hatched.	Brown-tail moth caterpillars, fourth stage.	Gipsy moth caterpillars.			Total.
		Fourth stage.	Fifth stage.	Sixth stage.	
1908.					
May 23	28	25	36	6	95
May 24	12	13	28	28	81
Do	14	12	14	35	75
May 25	5	19	38	10	72
May 26	5	15	35	21	76
May 27	5	13	34	30	82
Do	6	14	38	20	78
Do	5	20	18	24	67
Do	30	14	28	8	80
May 26	16	21	40	16	93
May 27	.....	22	36	21	79
May 28	31	.....	28	23	82
Do	.....	23	48	11	82
Do	.....	26	42	15	83
Do	.....	18	37	21	76
Do	.....	25	37	27	89

On June 19 a similar experiment was begun, and between that date and July 1 larvæ were added, so that, in all, 19 individuals were fed from the time of hatching until they were full grown. These larvæ developed from eggs laid by female beetles that came out of hibernation normally in June, 1908, while those in the previous set were the progeny of females that had been removed from hibernation and were fed in the laboratory under unnatural conditions.

TABLE VII.—*Food eaten by larvæ of Calosoma sycophanta.*

Date hatched.	Total food, sixth-stage gipsy moth larvæ.	Date hatched.	Total food, sixth-stage gipsy moth larvæ.
1908.		1908.	
June 19	33	June 20	52
Do	39	Do	37
Do	32	Do	48
June 20	43	Do	49
Do	43	Do	43
Do	45	Do	37
Do	31	June 21	45
Do	45	Do	37
Do	40	Do	40
Do	37		
		Average	41

The larvæ in Table VI required on an average 28 days to complete their feeding, while in Table VII only 14 days were necessary. The number of caterpillars consumed in the first was considerably greater than in the second series. This was largely due to the fact that those in the second series were fed entirely on sixth-stage gipsy moth caterpillars, while the other lot was furnished with smaller caterpillars for food. The average given in Table VII is probably the more correct index of what takes place under natural conditions in the field, and it shows that on the average a single larva of *Calosoma sycophanta* will destroy at least 41 full-grown gipsy moth caterpillars. The results shown in these two tables illustrate how impossible it is to attempt to accelerate the development of certain species of insects. While some of the parasitic forms will reproduce as long as a proper food supply is maintained and the temperature kept above a point where they seek hibernation, it has been impossible to induce the beetles of this genus to depart from their fixed habit of developing only one generation in a single year.

EXPERIMENTS IN FEEDING CALOSOMA LARVÆ WITH DISEASED GIPSY MOTH CATERPILLARS.

The question is often asked whether the larvæ of this species are susceptible to the disease commonly known as the "wilt," which each year destroys enormous numbers of gipsy moth caterpillars in badly infested colonies. In order to make a test, a limited number of experiments was carried on both in 1908 and 1909. The results in 1908 seemed to indicate that the larvæ suffered very little from this trouble, and in 1909 the tests were continued, but unfortunately the larvæ were fed in jelly glasses which proved too small to allow them to move freely after they became nearly full grown. The final results were similar to those secured the previous year, but it was thought best to make a further test in 1910. Ten larvæ that hatched on June 30 were fed in individual jars with gipsy moth caterpillars that showed signs of the "wilt." Feeding continued until July 15. One larva

PUPÆ OF THE GIPSY MOTH THAT HAVE BEEN DESTROYED BY THE LARVÆ OF CALOSOMA SYCOPHANTA.

Note the irregular holes, which are characteristic. (Original.)

died; 9 entered the ground and pupated, but 3 of these died in the pupal stage, so that only 6 adults emerged. The amount of food consumed was less than the amount usually eaten by a beetle larva of this species and averaged 30 full-grown gipsy moth larvæ.

The result of this experiment shows conclusively that this species suffers little if any from the "wilt." An examination of the rearing records indicates that the percentage of survival in these experiments compares favorably with that in those tests where healthy caterpillars are offered for food. In fact it seldom happens that 90 per cent of the larvæ that hatch can be reared to the pupal stage in confinement, and the loss of 30 per cent of the pupæ is not surprising when it is understood that pupation took place in jars containing only a small amount of earth, which rendered the transformation very difficult. The record of the feeding experiments of all the larvæ of *sycophanta* that hatched in 1907 shows that 15.5 per cent of the gipsy moth caterpillars furnished as food died from disease.

In field colonies it is quite common to find *Calosoma sycophanta* in localities where enormous numbers of gipsy moth larvæ and pupæ are dying from the "wilt" disease, and frequently larvæ of the Calosoma beetle are found feeding on the pupæ and on the caterpillars of the gipsy moth in masses which are badly diseased. Only one case has been observed of a dead Calosoma larva showing symptoms of the "wilt" disease, and the evidence in this instance was not at all conclusive. If the Calosoma beetles were susceptible, there is every reason to believe that at least some of the field colonies would have been practically exterminated by disease, but the results of repeated examinations in the field show exactly opposite conditions.

RESULTS OF FEEDING TO CALOSOMA LARVÆ CATERPILLARS FROM SPRAYED OR POISONED AREAS.

Owing to the practice of spraying for the purpose of controlling the gipsy moth, a method which has come into very general use during the past few years, fear has been expressed that the Calosoma beetles or their larvæ might be destroyed by feeding upon caterpillars that had devoured the poisoned foliage. During the past two summers attempts have been made to test this matter in the laboratory, but in the season of 1909 this work had to be discontinued on account of the large number of other experiments which was then being conducted.

In 1910 a series of experiments was planned—the idea being to spray a small area of low growing sprouts in which gipsy moth caterpillars were abundant, and to feed these caterpillars to the larvæ of the Calosoma and keep a close record of the result. The experiments were begun with the larvæ of *sycophanta* which hatched June 30, 10 individuals being used in the tests. From the beginning of the

experiments great difficulty was experienced in securing a sufficient supply of poisoned caterpillars. In areas that were thoroughly sprayed practically all the caterpillars died in a few days, but it was usually possible to find a few caterpillars that were apparently in a perfectly healthy condition. This was undoubtedly due to the fact that they had been feeding on foliage which was not thoroughly sprayed, or from which the poison had been washed by rain. Before the experiments were half completed it was impossible to secure caterpillars that had fed on poisoned foliage; hence, the results given are far from being conclusive. Two of the Calosoma larvæ, each of which ate 34 gipsy moth caterpillars, passed through their transformations and developed as perfect beetles, but the others died before reaching the pupal stage.

Observations in the field would indicate that where areas badly infested with the gipsy moth are sprayed, the Calosoma beetles will probably migrate to other sections where caterpillars are abundant. As it is impossible for the larvæ of the Calosoma to migrate, it is probable that if a large number of eggs was laid by the beetles a considerable proportion of the larvæ resulting would die from starvation on account of the lack of a sufficient number of caterpillars to furnish ample food supply. Undoubtedly some of the larvæ would be able to obtain sufficient food to pass through their transformations; hence there is relatively little chance of completely destroying this species as a result of arsenical spraying.

It is evident, however, in making liberations of Calosoma beetles in the field, that this should be done in localities where spraying will not be attempted, in order that the insects may have every opportunity to develop and increase. This policy has been followed, and in only a few cases has the spraying of the territory where the beetles were liberated been permitted, and then only when it became apparent that serious defoliation would result unless the work was done. It is evident that as soon as the species becomes firmly established and dispersed over a large area, as is now the case in a portion of the infested district, spraying will have little effect on the number of specimens which will develop.

EXPERIMENTS IN FEEDING GIPSY MOTH PUPÆ TO CALOSOMA LARVÆ.

The larvæ of *Calosoma sycophanta* are very fond of gipsy moth pupæ and destroy large numbers of them in the field. In order to determine how many are eaten, a series of experiments was begun with 10 Calosoma larvæ that hatched July 11, 1910. They were fed separately upon gipsy moth pupæ until they were fully developed and descended into the ground to pupate. The average number of pupæ which each beetle larva consumed was 13. In the course of this experiment it appeared that more female pupæ

were eaten than males, and another test was begun by Mr. Collins to determine whether this preference was constant.

Ten larvæ that hatched July 21 were isolated in jars and furnished with 3 male and 3 female gipsy moth pupæ, which number was increased as the larvæ grew and became more voracious. In this experiment each larva averaged to destroy 12 pupæ, 17 per cent of which were males and 83 per cent females. In one case an adult female gipsy moth was eaten by a Calosoma larva when pupæ of the gipsy moth of both sexes were present in the jar.

In order to check this experiment three localities were visited by Mr. J. V. Schaffner, jr., and Mr. H. L. MacKenzie for the purpose of collecting the molted skins of Calosoma larvæ and making counts of the number of male and female gipsy moth pupæ that had been destroyed.

The first locality selected, in the Lynn woods, was badly infested with caterpillars earlier in the season, and the larvæ of *sycophanta* had been found plentiful. All the trees had been banded with tanglefoot, but owing to the fact that a considerable number of eaten pupæ, as indicated by the empty pupal shells, was found above the sticky bands, it is probable that the bands had been applied rather late in the season. Trees were also examined in two other localities several miles from the Lynn woods, viz, at Mount Hood, Mass., near the Melrose and Saugus line, and at Pine Banks Park, Malden, Mass. In these two localities there was no tanglefoot on the trees. A few of the trees at Pine Banks Park were burlapped and most of them had been sprayed. The trees were climbed and a record kept of all male and female gipsy moth pupæ that had been eaten by the Calosoma larvæ. The results for 20 trees examined showed that 24.5 per cent of the gipsy moth pupæ eaten were males and that 75.5 per cent were females. These data correspond very closely with those secured under laboratory conditions and indicate that the preference of the larvæ for female pupæ is pronounced under field conditions. The effect of the preference of the Calosoma larvæ for the female pupæ of the gipsy moth is thus very apparent and indicates that the benefit which is likely to accrue from this species may be greater than was at first anticipated.

EXPERIMENT IN FEEDING EARTHWORMS TO LARVÆ OF CALOSOMA.

In order to determine whether the larvæ of *Calosoma sycophanta* will feed on other than insect food, 5 newly hatched individuals were supplied with earthworms, as they had proved an acceptable diet for several species of Carabus received from Europe. All the Calosoma larvæ died in the first stage, and none of the earthworms was eaten, 4 of the larvæ lived 4 days, and 1 died at the end of 2 days. This

experiment served to indicate the approximate length of time which young larvæ can survive without food, although a more detailed experiment of this sort follows.

STARVATION EXPERIMENT APPLIED TO LARVÆ OF CALOSOMA SYCOPHANTA.

Early in the spring of 1908 a series of experiments was carried on, using 5 beetle larvæ in each stage in order to determine how long they would remain alive and active without food.

August 3, 1908, 5 newly hatched beetle larvæ were placed in jars of earth without food; 2 larvæ died in 3 days, 2 in 4 days, and 1 in 5 days.

August 3, 1908, 5 larvæ that had just passed the first molt were placed in jars of earth without food; 1 larva died in 6 days, 3 in 7 days, and 1 in 9 days.

August 6, 1908, 5 larvæ that had just passed the second molt were placed in jars of earth without food; 2 larvæ died in 8 days, 1 in 10 days, and 1 in 16 days.

The remaining larva, after having been confined, without food, in a jar for 9 days, was offered fall webworms. It consumed 5 larvæ in 3 days, but at the end of that time died.

This experiment shows that the older Calosoma larvæ are able to survive without food for a longer period than the younger ones. In nature they will probably live longer than the time indicated, as they would be able to obtain considerable moisture which would help to prolong life.

In order to determine how late in the summer it is possible to plant larval colonies of *Calosoma sycophanta* successfully, two experiments were tried in 1908.

On August 7, 1908, 100 Calosoma larvæ that had passed the second molt were liberated in woodland at Waltham, Mass. No gipsy moth caterpillars were present at the time, but a few newly hatched brown-tail moth larvæ were feeding on the trees. No native caterpillars were observed at the time the Calosoma planting was made.

In the spring of 1909 the trees in this colony were burlapped and examinations were made at intervals throughout the summer. In September a molted larval skin of the Calosoma was discovered on one of the trees, and the following summer (1910) beetles, larvæ, and molted skins were found, showing that some of the Calosoma larvæ in the original planting had developed and that the strength of the introduced colony was increasing.

In order to test the matter under still less satisfactory food conditions, a colony of 100 third-stage Calosoma larvæ was liberated in the oak woodland at Tewksbury, Mass., August 12, 1908. The larvæ were placed at the base of each of six oak trees, the foliage of which was being eaten by small brown-tail moth caterpillars. This colony

was burlapped and examined the same as was the one at Waltham, Mass., but no traces of Calosoma beetles have since been found.

The results in these field colonies show that the beetle larvæ are sometimes able to develop even when the food supply is very scanty.

Experiment to Determine Whether Calosoma Larvæ Will Hibernate During the Winter.

A Calosoma larva which hatched August 7, 1907, and became nearly full grown September 7, was placed in a cavity 6 inches below the surface of the earth in a galvanized-iron cage out of doors.

May 19, 1908, the cage was taken up and a dead Calosoma beetle was found in the cavity where the larva had been placed. The death of the insect was caused by the pressure of the earth upon it. The weather was cool from the time the larva was buried until the date of removal, hence this experiment shows that the insect does not normally, and probably can not, hibernate in this stage.

Placing Calosoma Larvæ in Cold Storage to Determine Ability to Withstand cold.

The following experiment was tried to test the ability of larvæ of this species to withstand cold.

August 8, 1907, two lots, each containing 4 Calosoma larvæ (2 newly hatched larvæ, 1 larva 6 days old, and 1 full-grown larva), were sent to cold storage, where a temperature of 28° F. was maintained. The smaller larvæ were placed in separate vials which contained about 3 inches of earth, and plugged with cotton, while the full-grown larvæ were placed in jelly glasses containing about 2 inches of earth.

August 22, 1907, one lot was removed from storage. The 2 newly hatched larvæ were dead on top of the earth. The other 2 larvæ were in the ground and were apparently dead.

August 27, 1907, another examination was made. All larvæ failed to revive, and the experiment was closed.

June 4, 1908, the second lot was removed from storage. The earth was very dry in both vials and jelly glasses. All larvæ were dead.

These results indicate that the larvæ will not survive cold storage, but if they are full grown and are subjected to a gradual reduction of temperature they will pupate and transform to beetles before becoming dormant.

Methods Used in Rearing Calosoma Larvæ.

During the progress of the work many experiments have been tried in order to ascertain the best methods of rearing the Calosoma larvæ. If only a few specimens are desired for study the use of a small jar

for each individual larva provides an excellent way of handling them, but when large numbers are to be reared for field liberation it is desirable to adopt some method that will save as much time as possible and at the same time insure the development of most of the specimens. Owing to the cannibalistic habits of the Calosoma larvæ in all stages it is necessary to furnish large quantities of food if many are to be fed in the same container. If these conditions are maintained a considerable number of the larvæ can be fed in the same jar or cage until after the second molt.

Early in August, 1908, 5 newly hatched larvæ were placed in a Fiske tray (fig. 17) without earth. They fed in this tray and molted twice before showing any inclination to attack each other. After this time 3 of the larvæ were killed by their comrades and as similar experiments gave the same result it is apparent that they can not be kept longer in close quarters.

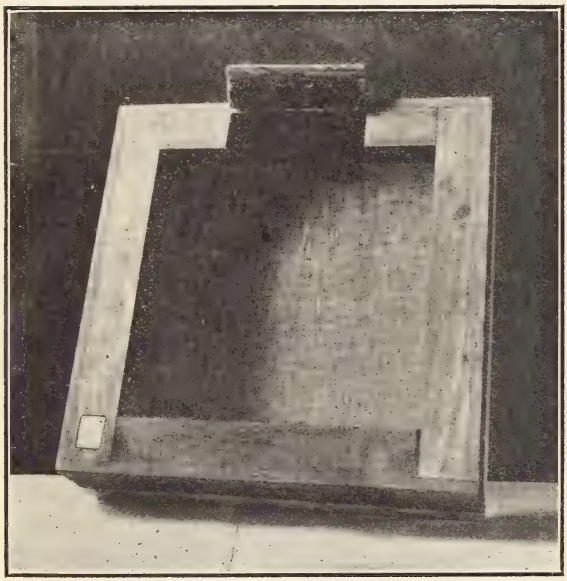


FIG. 17.—A "Fiske tray" for feeding gipsy moth caterpillars. A section at the top has been sawn out and bent back to show the tanglefooted band which prevents the caterpillars from escaping. (Original)

Another experiment was tried using a large Fiske tray 5 feet long and 2 feet wide. Ten Calosoma larvæ 2 days old were placed in it with food and a quantity of leaves. Eight larvæ passed through the first molt successfully, 6 through the second—these were left in the tray—and at the time of the final examination only 1 remained. Apparently some of them grew faster and killed the others while searching for food.

In another test where 5 small larvæ were placed in a small Fiske tray and were removed after they had molted once, all survived.

The facts thus obtained have been made use of in rearing larvæ for field liberation. Ten to fifteen Calosoma larvæ were placed in a large battery jar containing earth, and plenty of food was supplied. The larvæ were removed usually after molting once, but in some cases they

molted twice in the jars. The mortality for the season of 1909 was 10 per cent of the 8,280 larvæ which were fed in this way, and for 1910 it reached 12 per cent of the 8,720 larvæ that hatched. It is interesting to compare these figures with those for the year 1908 when a smaller number of larvæ was fed individually in jelly glasses provided with cheesecloth covers. A considerable number of larvæ escaped by forcing their way through the covers and in all 13.8 per cent of the total for the year (2,854) were either lost or died. This shows that the improved covers used on jars the following years and the experience gained in handling the larvæ have resulted in reducing the mortality.

Since the work began, July 23, 1907, nearly 20,000 Calosoma larvæ have been cared for and most of these have been liberated in the field.

In August, 1909, a considerable stock of Calosoma larvæ was on hand at the laboratory, and as it seemed advisable to feed and carry them through the larval stages and hibernation where they could be under direct observation they were placed in large box cages (see Pl. V) set in the ground. These were 2 by 3½ feet in size, and were provided with a fine wire-netting bottom so that the larvæ could not escape. The earth in the cages was 15 inches deep.

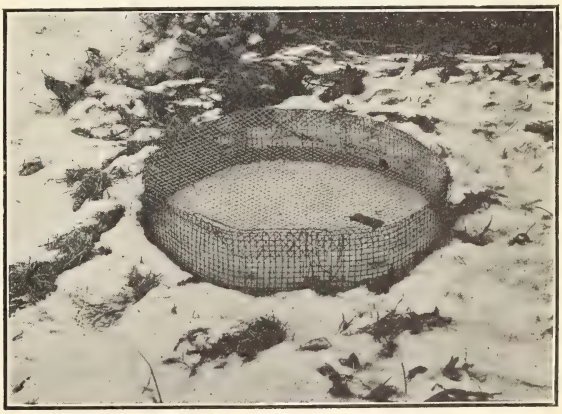


FIG. 18.—Wire-screen hibernation cylinder where larvæ of Calosoma were fed in August, 1910. Photographed February, 1911. (Original.)

Several cylinders of galvanized iron wire, 17 inches in diameter, were also constructed for the same purpose and were sunk in the ground and later stocked with larvæ and food. (See fig. 18.) These cylinders were lined on the inside with mosquito netting and the tops and bottoms were made of the same material.

One thousand three hundred and eight second and third stage Calosoma larvæ were placed in these cages or cylinders between July 30 and August 27, 1909, and of this number 210 larvæ, or 16.6 per cent, were killed by their comrades. The food supply was of necessity very poor in quality, especially after the middle of August when gipsy moth larvæ and pupæ that had been held in cold storage were furnished, many of which were in a badly decomposed condition.

The following year (1910) 1,224 larvæ were placed in similar cages or cylinders between July 26 and August 16, and only 5 per cent were killed by their comrades. Some cold storage gipsy moth pupæ were supplied, but they were in very good condition for feeding to the Calosoma larvæ.

The Distance Calosoma Larvæ Penetrate the Ground to Pupate.

The distance which the larvæ of this species penetrate the ground for the purpose of forming their pupal chambers varies greatly, and seems to be governed largely by the character of the soil, and the amount of moisture which it contains.

Few observations have been made on Calosoma larvæ that feed under natural conditions, as it is a difficult matter to find hibernating beetles in the ground, even in our most prosperous colonies.

It is probable that if the ground is hard and dry—as is usually the case in midsummer—the larvæ are not able to descend for more than a few inches below the surface. In one of our cages during the summer of 1909 a larva burrowed under a board and formed a pupal chamber beneath it, so that a living pupa was readily exposed by lifting the board. The cage experiments at the laboratory do not offer typical data on this point, for the reason that it is necessary to fill the cages with fresh earth when they are set in the ground early in the summer, so that the soil is not as compact as it would be under natural conditions. In 1908, several larvæ pupated in jars partly filled with earth. As a rule the pupal cavities were made at or near the bottom of the jar, and these were from one-half an inch to 3 inches below the surface.

A record of 20 Calosoma pupæ—12 males and 8 females—which made cavities, during the fall of 1908 and 1909, shows that they penetrated from 4 to 8 inches below the surface in outdoor cages. The average distance for males was $6\frac{2}{3}$ inches and for females $7\frac{1}{4}$ inches. Seven males and 5 females went to the bottom of a cage which contained 8 inches of soil. Under natural conditions the Calosoma larvæ probably will not burrow more than from 4 to 5 inches into the ground before making the pupal chamber. Thus the insect must remain considerably above the frost line during the winter. In some rare cases Calosoma larvæ have successfully pupated on the surface of the ground, and in nature they may sometimes pupate under the leaves or vegetable mold in forest areas.

The distance that the Calosoma larvæ go into the ground to form their pupal chamber corresponds very well with the distance which the Calosoma beetles will burrow for the purpose of going into hibernation, and several records bearing on this point will be given later under the head of hibernation of the beetles.

THE PUPA.

The Pupal Chamber.

The pupal chamber or cell is formed by the full-grown larva. As soon as feeding is completed the larva becomes somewhat shorter and thicker, makes its way into the ground, and by means of burrowing and moving the body about, forms the chamber in which to pupate.

The pupa rests in this cavity (fig. 19) on the dorsum, where it remains until the beetle emerges.

Description of Pupa.

Length 25 mm., width at first abdominal segment 12 mm. Color pale yellow. Head depressed, only a small portion of the pronotum being visible from above. Dorsal part of thoracic segments smooth, shining. Lateral edges of first abdominal segment rounded behind. On the second to sixth segments, inclusive, the lateral edges are thickened and dark brown in color, and protrude slightly over the stigmata. The former are slightly hollowed out in front and bluntly toothed behind. The segments following are not thickened laterally. A thick brush of brown hairs is present on the dorsal part of the first five abdominal segments, also a smaller one on the eighth segment; sometimes less prominent ones occur on the sixth and seventh segments. Spiracles somewhat protected by lateral brushes. Mouth parts, antennæ, wings, and legs folded beneath the head. Hind pair of legs extending to the tip of the abdomen. Wings extending beyond the fourth abdominal segment.

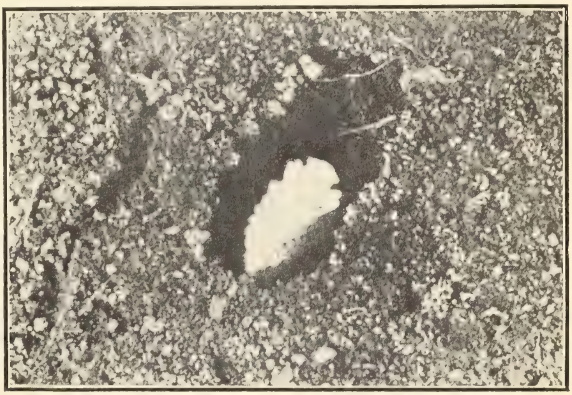


Fig. 19.—Pupa of *Calosoma sycophanta* in cavity in the earth. (Original.)

Experiments with the Pupæ of Calosoma sycophanta.

Several experiments have been tried by removing pupæ from their natural pupating cavities and placing them in jars or artificially constructed cavities in order to determine whether they can be safely handled in this stage. In a number of cases no disastrous results followed their removal, and they can be safely treated in this way, provided the artificial cavity in which they are placed remains intact, so that no lumps of earth or other substances fall in upon the pupæ and thus prevent the normal emergence of the beetles. As a rule it is difficult to secure these conditions with any degree of cer-

tainty, and it is therefore better to avoid disturbing the larva after it has descended to form the pupal cavity.

During the fall of 1907 it seemed desirable to ascertain if it was possible for Calosoma larvæ which hatched from eggs laid late in the season to enter the pupal state and so remain during the winter.

Ten pupæ were used in this experiment, and were treated in three different ways. One lot was placed in galvanized-iron cages, another in mosquito-netting cages out of doors, and the third lot pupated in jars, which were placed in a cool cellar during the winter.

EXPERIMENT IN WINTERING CALOSOMA PUPÆ IN GALVANIZED-IRON CAGES.

The galvanized-iron cages were made in the form of a cylinder, 4 inches in diameter and 24 inches long, and were sunk into the ground 20 inches. The ends of the cylinders were covered with mosquito netting.

On September 6, 1907, 5 pupæ were removed from the pupal cavities in the jars in which they had previously transformed, and on the following day another specimen was secured, and each of the 6 was placed in a separate cage at depths of 4, 6, 8, 10, and 14 inches below the surface, an artificial cavity at these depths being made in the soil.

May 19, 1908, the cages were examined, and it was found that all the Calosoma pupæ had transformed to beetles. Two females were alive, although one had been partly crushed by the settling of the earth in the cylinder, while 2 males and 1 injured specimen, which could not be determined as to sex, were also found.

Cages of this type proved impractical for hibernation experiments.

EXPERIMENTS IN WINTERING CALOSOMA PUPÆ IN WIRE-NETTING CAGES.

Two pupæ were used in the experiments with wire-netting cages, but the results with one of these was not determined owing to an accident.

The cage consisted of wire mosquito netting, which was attached to the trunk of a tree, and extended about a foot below the surface of the ground, the top being covered with the same material. On September 6, 1907, the Calosoma pupa from which the only record was secured was placed in a cavity made about 4 inches below the surface.

May 18, 1908, this cage was dug up and a live male beetle found in the cavity.

EXPERIMENTS IN WINTERING CALOSOMA PUPÆ IN A COOL CELLAR.

Jars containing 4 Calosoma pupæ were removed to the cool cellar of the laboratory on September 20, 1907, and early in October they were transferred to another cellar where the temperature was slightly above freezing during the winter, and which was very damp.

On March 4, 1908, two jars were removed from the cellar and kept in the laboratory at room temperature. In one of these the fully formed beetle could be seen in a cavity at the side of the jar. On April 13 this beetle, which proved to be a female, emerged and fed, and on April 16 the remaining beetle, also a female, came to the surface and began feeding.

The other two jars were not removed until June 9. A dead beetle which had previously emerged was found on the surface of the ground in one of them, while in the other a live male was found in the cavity.

To check these experiments, three jars, each containing a pupa, were placed in cold storage September 7, 1907. One pupa had transformed in a jelly glass 1½ inches below the surface of the earth. This glass was put into a battery jar containing 1 inch of earth and enough more was added around the sides of the jelly glass to make the earth level in both jars. The second pupa had transformed in earth, in a jelly glass, and the third pupa, in a battery jar, was located in a cavity 2 inches below the surface of the earth. On June 5, 1908, all the jars were removed from cold storage. The pupa in each case was dead. In one of the glasses, and in the battery jar, the earth was very dry. The death of the pupæ was due presumably to the sudden reduction in temperature to about 28° F., no rise in temperature being noted during the entire period of storage.

These experiments indicate that the Calosoma beetles normally emerge from the pupa in the fall and hibernate in the adult form during the winter, as this was the case in the first set of experiments, even though the temperature was reduced considerably below normal.

Length of Time Spent by Calosoma sycophanta in the Pupal Stage.

It is somewhat difficult to ascertain the exact length of time spent in the pupal stage, for the reason that several days elapse from the time the larva stops feeding until actual pupation takes place.

In the season of 1910 notes were made on eight larvæ that pupated in jars of earth in such positions that their movements could be observed. The length of time from cessation of feeding until pupation actually took place was from 7 to 15 days, the average time being 10½ days. In one case a larva pupated on July 27, 1908. On August 2 the legs were becoming darker in color, and on August 4 a female beetle emerged. The elytra were still soft, and some little time was required for the beetle to become fully developed and active. A few days later it entered the ground and formed a cavity, where it remained for hibernation. In two other cases from 10 to 11 days were required for the pupa to pass through that stage.

On August 20, 1909, a fully formed pupa was found in a cell under a board in one of the out-of-doors cages, and careful notes were made

daily by Mr. S. S. Crossman. It was white, and evidently had just pupated. Mr. Crossman's memorandum contains the following notes:

August 23: Legs, eyes, and mouth parts have become pale pink in color.

September 3: Eyes nearly black, tips of mandibles black.

September 6: Mouth parts black, legs and tip of abdomen becoming darker in color. The body is of a dirty cream color.

September 8: Eyes and mandibles black. Legs and antennæ brown. Tip of abdomen darker in color.

September 9: Legs and antennæ growing darker; tibiæ and tarsi black; clypeus brown.

September 10: The entire pupa is much darker to-day.

September 11: Beetle emerged at 8.15 a. m. The elytra are pale brown in color. At 12 m. they had become brownish green, and at 3 p. m. metallic green, which is characteristic of newly emerged beetles. The body is still soft, and the beetle has not left the cell.

September 13: Beetle left pupal cavity early this morning.

The length of time in this stage will be governed largely by the temperature as it will be noted that the pupæ first cited transformed to adults in about one-half the time required by the one last mentioned. A good set of records was secured in 1910 and they are probably typical for jar experiments. When the larvæ pupate in the ground, doubtless the time required is somewhat greater.

The records of 10 pupæ, 6 males and 4 females, ranged from 12 to 15 days, the average being 13.4 days.

THE ADULT OR BEETLE.

Emergence of Calosoma Beetles in the Spring.

Only a few records were kept in the spring of 1908 of the emergence of Calosoma beetles which developed from pupæ in the fall of 1907, as most of the specimens reared were used for experiments to test the ability of the beetles to hibernate and the cages were dug up before the time of normal emergence.

In the spring of 1909 the time of emergence for 16 males and 17 females that transformed from pupæ in the summer of 1908 ranged from June 8 to 21, the average time being June 13. The first two weeks in June were unusually cool for the season of the year, the temperature averaging much lower than in 1908.

A similar record of 512 beetles in the spring of 1910 showed that the emergence took place from May 11 to June 28, the average date being June 2.

Hibernation is so closely related to emergence that it is considered at this point.

Hibernation of Calosoma sycophanta.

In the summer of 1907 it was found that as soon as the food supply was reduced, the Calosoma beetles became inactive, and if given an opportunity they went into the ground and remained in a somewhat

dormant condition. The specimens that were under observation that year could not be expected to behave in a normal manner, because they were received about July 20, and were collected possibly three weeks before, so that they were deprived of food during the height of the feeding season.

They went into hibernation from August 12 to September 16, 1907, although some would probably have entered earlier if a large supply of food had not been offered them.

This species always burrows into the ground to spend the winter, unless the soil is so hard that this is impossible. Occasional specimens may remain beneath leaves or mold in wooded areas, but we have no data to show that this habit is normal, as is the case with some of the species of Carabus. The hibernation cages used have been supplied with earth which was rather loose and offered an excellent opportunity for the insects to burrow.

The cavities range from 2 to 15 inches, but some have been found 20 inches below the surface of the ground. Calosoma beetles seldom go below the frost line. They remain in these cavities until warm weather, when they come to the surface of the ground in search of food.

The weather has a most important bearing on the emergence in the spring, but in general it may be said that Calosoma beetles will seldom be found before June 1, which is a week or more after most of the gipsy moth larvæ have hatched.

Table VIII shows the average dates of entering hibernation.

TABLE VIII.—*Average dates of entering hibernation by Calosoma sycophanta.*

Year.	Number of beetles.		Age of beetles.	Average date males entered hibernation.	Average date females entered hibernation.
	Males.	Females.			
1908	11	11	Old	Aug. 17	Aug. 15
	12	14	Young	July 14	July 16
1909	103	83	Old	Aug. 8	Aug. 5
1910	38	39	do	Aug. 1	July 31

This table indicates that the males and females enter hibernation at practically the same date; while there is considerable variation in different years, the average is about August 1.

The date when the beetles went into hibernation in 1907 was much later than normal, as the specimens were not received from Europe until late in July and were given a liberal supply of food. The record of beetles for the next year is more nearly correct, as the only ones included were those that had been used in reproduction operations during the season. Old beetles are those that have entered hibernation for the second time, while young beetles are those that pass through

hibernation in the pupal cavity. The date when young beetles go into hibernation depends almost entirely on the time when the eggs are laid and whether the larva has an abundance of suitable food. July 14 and 16 were the averages dates for males and females for the year 1908.

TABLE IX.—*Average date of emergence of Calosoma sycophanta from hibernation.*

Year.	Number of beetles.		Age of beetles.	Average date males emerged from hibernation.	Average date females emerged from hibernation.
	Males.	Females.			
1908	6	7	Old	June 4	June 3
1909	34	39	do	June 8	June 10
	15	17	Young	June 13	June 13
1910	261	251	do	June 1	June 3
	58	46	Old	June 6	June 7

The date of emergence depends on the weather and on the location in which the beetles spend the hibernating period.

During the spring of 1909 the weather was very cool in May and in early June, and as a consequence the average dates of greatest emergence extended from June 8 to 13, while the following year the average extended from the 1st to the 7th of June.

From the table above, which contains the records of 734 specimens, it will be noted that there is very little difference in the date of emergence of males and females. A greater discrepancy is shown between the old and young beetles, but this is probably more apparent than real, as the earth was very loose in some of the cages, so that the beetles hibernated very deep in the ground, and hence their emergence was delayed. The earliest date of emergence is May 8 and the latest June 29.

In general it can be said that most of the emergence will take place in the field during the first week in June, beetles having been found on or before June 4 during the past three years.

MORTALITY OF CALOSOMA BEETLES DURING HIBERNATION.

During the winter of 1908–9, 35 per cent of the old male beetles and 25 per cent of the old female beetles died, and the following winter 31 per cent of the old male beetles and 27 per cent of the old female beetles died. Of the young beetles 22 per cent of the males and none of the females died during the winter of 1909–10. This data would seem to indicate that about one-third of the old beetles die during the winter. The mortality of the young beetles in hibernation on the average is probably less than 20 per cent.

These results were secured from beetles that hibernated under favorable conditions. It was necessary to conduct a number of

careful experiments in order to determine the best cages to use for the hibernation of these insects, and the results of these various tests are given in order that others who may desire to carry on similar work may profit by this experience.

Experiments in Wintering Calosoma Beetles in Galvanized-Iron Cages.

In the fall of 1907 it became necessary to place as many beetles as possible in hibernation cages so that a supply would be available for the rearing work of the following spring, as well as to make a thorough test of the ability of this species to withstand a New England winter. Several styles of cages were used for the purpose, and as it was desired to place them out of doors a number of cages was constructed of galvanized iron. They were made in the form of a cylinder, 20 inches long and 4 inches in diameter. A flange was turned on the upper and lower edges so that wire netting could be attached by means of a wire which encircled the cylinder at the base of each flange. They were set in the ground so that 2 or 3 inches of the cage protruded. Beetles were placed in these cylinder cages in September, 1907. The following spring it was found that these cages were very unsatisfactory for the purpose, as two-thirds or more of the insects placed in them had died during the winter. The chief trouble appeared to be due to the freezing and thawing of the earth in the cylinder, which rendered it very compact, and in many cases the beetles were crushed in their hibernation cavities or were unable to make their way through the wet soil early in the spring. Fortunately, several other styles of cages were used and better results with them were secured.

Experiments in Wintering Calosoma Beetles in Wire-Screen Cages.

Several hibernation cages were made of galvanized-wire screen having a $\frac{1}{4}$-inch mesh. This material is commonly used for screening cellar windows, and it forms an excellent cage. (See fig. 9, p. 18.)

Several experiments were also tried in using cages made of mosquito netting sunk into the ground and attached on one side to the trunks of trees. The results with these cages were satisfactory, but as the wire rusted badly it is impossible to use them for more than one season, so that the cage previously mentioned is more desirable.

Experiments in Wintering Calosoma Beetles in Box Cages.

For hibernating large numbers of beetles use has been made of tight wooden boxes about 24 inches deep, provided with galvanized iron wire bottoms and covers, and these have proved satisfactory. (See fig. 8, p. 17.)

Effect of Removing Calosoma Beetles from Hibernation Early in the Spring.

In the spring of 1908 several series of experiments were conducted in order to determine whether it is possible to remove Calosoma beetles from hibernation before the normal time, feed them under laboratory conditions, and be able to produce more than one generation of beetles a year. If this work could be carried on it would be of considerable biological interest and would increase the number of specimens that could be liberated in field colonies. In order to make these tests, several cages containing hibernating Calosoma beetles were removed from the ground March 4, 1908. The weather was very cold, and it was necessary to cut through from 7 to 14 inches of frost before the cages could be taken out. They were brought to the laboratory and allowed to warm up gradually with the expectation that the beetles would emerge from the earth in a short time, begin feeding, and deposit eggs. As a matter of fact, they emerged slowly, and after reaching the top of the earth in the cages they were placed in jars of earth and furnished with caterpillars which were being reared in the laboratory. Similar lots of beetles were removed from hibernation in April and May. The results of the experiments indicate that it is possible to remove beetles in this way, but an extra generation can not be developed during the summer. The larvæ did not become full grown much sooner than those that developed from eggs laid at the normal time.

Feeding Habits of the Adults.

The adults climb trees, travel out on the branches and twigs, and occasionally cling to the leaves while searching for caterpillars. If disturbed, they fall to the ground and instantly seek shelter under leaves or rubbish. Gipsy-moth and brown-tail moth caterpillars are attacked while the Calosoma beetles are in the trees, the favorite point of attack on the caterpillar being in the middle of the back. They are firmly grasped by the sharp mandibles of the beetle, and after many frantic efforts on the part of the victim to escape the integument is ruptured and the beetle proceeds to feed on the contents of the body. Very rarely does the gipsy-moth or the brown-tail moth caterpillar escape without serious injury, and this never occurs if a firm hold is once secured by the predatory Calosoma. Occasionally beetles will be seen carrying the caterpillars in their jaws.

Length of Feeding Period of the Adults.

The active feeding period of Calosoma beetles extends from the date the beetles emerge in the spring from hibernation until about two weeks before they enter hibernation in the fall. But little food is consumed during the two weeks immediately preceding entrance

into hibernation, and, as a rule, the beetles are rather sluggish in movements.

Many records have been secured, but the most typical are perhaps the ones obtained during the summer of 1910. Twelve pairs of Calosoma beetles were kept under observation, being fed in jars. There were 4 pairs of old beetles, the same number of young beetles, old males and young females, and old females and young males.

The earliest emergence was noted on May 25 and the latest on June 5. Feeding was completed between July 5 and August 9. The shortest feeding period was 32 days and the longest 66 days, with 50 days as an average.

The feeding period corresponds fairly well with that of the caterpillars of the gipsy moth. The beetles do not emerge at quite as early a date in the spring as that upon which the gipsy moth caterpillars hatch, and in the fall the gipsy moth has transformed and deposited its eggs before the Calosoma beetles seek hibernation.

Food of the Adults.

The food of the adult beetles is similar to that of the larvæ. Each year some of the Calosoma beetles have been fed on native lepidopterous larvæ and none of the species offered was rejected by them.

If the weather is cool in the early summer, the beetles remain on the ground, usually under leaves or litter, and sally forth on the first warm days in search of food. As soon as caterpillars become scarce, late in July or early in August, the beetles feed less and spend most of the time beneath the ground, soon burrowing down to form the hibernating cell.

Elaborate experiments have been conducted each year since 1907 to determine the number of gipsy-moth caterpillars that are destroyed by these predaceous beetles and a mass of data has accumulated from which typical results have been selected. The most complete series of experiments was conducted during the year 1910, and the results are summarized in Tables X, XI, and XII.

Sixth-stage tent caterpillars and gipsy-moth caterpillars were used, as they were of about the same size and offered a fairly uniform ration on which to base the average amount of food consumed.

Table X.—*Feeding records of 4 pairs of young Calosoma beetles, 1910.*

Pair No.	Emerged from hibernation.	Ceased feeding.	Sixth-stage caterpillars consumed.		
			Tent.	Gipsy moth.	Total.
4804	May 26	July 15	76	165	[1] 241
4805	...do....	...do....	135	39	174
4806	...do....	July 13	120	226	[1] 346
4807	...do....	July 8	60	35	95

[1] Females laid eggs.

TABLE XI.—*Feeding records of 4 pairs of old Calosoma beetles, 1910.*

Pair No.	Emerged from hibernation.	Ceased feeding.	Male died.	Female died.	Sixth-stage caterpillars consumed.		
					Tent.	Gipsy moth.	Total.
4808	May 25	July 20	July 25	July 12	102	204	[3] 306
4809	...do...	...do...	.....	July 24	95	194	[3] 289
4810	May 26	.....	[1] July 7	[2] July 11	57	237	[3] 294
4811	June 3	.....	.....	[2] July 5	149	179	[3] 328

[1] Added male No. 4811. [2] Record discontinued. [3] Females laid eggs.

TABLE XII.—*Feeding records of Calosoma beetles, 1910.*

Pair No.	Emerged from hibernation.	Ceased feeding.	Female died.	Sixth-stage caterpillars consumed.			
				Tent.	Gipsy moth.	Salt marsh.	Total.
Old males, young females:							
4812	May 26	July 18	.....	110	106	.....	216
4813	June 4	Aug. 9	.....	87	97	4	188
Young males, old females:							
4814	June 3	Aug. 2	Aug. 3	104	357	.....	[1] 461
4815	June 5	July 18	.....	105	125	.....	[2] 230

[1] Female laid eggs. [2] Female laid eggs; did not hatch.

These tables show, on the average, that the old Calosoma beetles consume more food than young ones. This is undoubtedly due to the greater reproduction which is common with the former.

The average for the old beetles was 328 caterpillars and for the young beetles 239, while the average for all the pairs given in Tables X, XI, and XII is 272 caterpillars. This is a fair average, as nearly as can be determined, of the number of caterpillars that the Calosoma beetles will actually destroy. In the field probably the number would be increased, as feeding under natural conditions would undoubtedly stimulate activity and appetite.

In addition to the large number of experiments that has been carried on to determine the amount of food that will be eaten by Calosoma beetles that emerge from hibernation at the normal time, several series were conducted with beetles that were taken from hibernation in March, April, and May. These beetles did not become active and begin feeding for a considerable time after the cages were removed to a warm room in the laboratory, but as small caterpillars of various species, particularly brown-tail moth larvæ that were being fed in the laboratory, were used for food, large numbers were destroyed before midsummer. Most of these caterpillars were small and as soon as the Calosoma beetles became active large numbers were required to satisfy their hunger.

The average number of small brown-tail moth caterpillars eaten by 3 pairs of Calosoma beetles removed April 9, 1908, was about

2,000 caterpillars per pair of beetles. This indicates that the number of caterpillars consumed, and hence the amount of benefit derived, depends to a considerable extent on the size of the prey, and, further, that if gipsy moth caterpillars should be scarce in any locality a great number of the smaller native species would be destroyed.

EFFECT OF FEEDING DISEASED GIPSY MOTH CATERPILLARS TO CALOSOMA BEETLES.

Among the feeding experiments begun in July, 1907, was one to test the effect, on the health of the Calosoma beetles, of feeding them diseased gipsy moth larvæ. In the other feeding experiments where gipsy moth larvæ were used it was found that 15½ per cent of them died from the disease known as the "wilt." A single pair of Calosoma beetles was fed, from July 23 to August 14, with caterpillars which showed pronounced symptoms of the disease. Twenty-one larvæ were eaten, 3 were so badly injured that they died, and the remaining larvæ supplied to the beetles in the jar died from disease. These beetles ate slightly less than in the case of other pairs that were fed healthy food, but showed no bad effects and went into hibernation at the same time as the other pairs. Unfortunately they were placed in a galvanized-iron cage and died before spring, as was also the case with other pairs that were wintered in the same kind of cages. The death of these beetles may, therefore, be attributed to the unsuitability of the cage rather than to action of the diseased food consumed.

July 8, 1910, an experiment was started with 2 pairs of old beetles. One pair ate voraciously; the female oviposited freely, and died August 16 following. The other pair ate very little, no eggs were laid, and both beetles went into hibernation in August.

All the experiments conducted would seem to indicate that the beetles of *Calosoma sycophanta* are not susceptible to the "wilt" disease.

Each year large numbers of the gipsy moth caterpillars die in the feeding jars from this disease, and if it were seriously destructive to the Calosoma beetles or their larvæ it would long ago have been necessary to give up the experimental and rearing work.

EXPERIMENTS IN FEEDING CALOSOMA BEETLES WITH GIPSY MOTH CATERPILLARS FROM SPRAYED OR POISONED FOLIAGE.

Several attempts have been made to determine whether adult Calosoma beetles are injured or killed by feeding on gipsy moth caterpillars taken from sprayed trees. In 1910 an attempt was made to test this matter, and a small area of brush and scrub growth near the laboratory was sprayed with arsenate of lead and the gipsy moth caterpillars collected later from time to time, in order to make a test. The experiments were begun on June 17, 1910, and gipsy moth caterpillars from this poisoned area were used for food until July 13,

with the exception of the few days from June 19 to June 26, when caterpillars from other and unsprayed localities were used. One male Calosoma died July 18 and a female died on July 29. The other beetles went into hibernation at the normal time. The experiment indicates that neither of the beetles that died was injured by the food supply. It is probably true that most of the caterpillars taken from the sprayed area had no great amount of poisoned leafage in their bodies, otherwise they would have died. Under natural field conditions Calosoma beetles of this species may migrate from sprayed areas, either immediately after spraying or as soon as caterpillars commence to show the effects of the poison, as the caterpillar food supply is greatly reduced and the beetles naturally seek localities where caterpillars are plentiful.

Experiment in Feeding Calosoma Beetles on Beefsteak.

Calosoma beetles that were placed in cold storage August 15, 1908, were removed in March and May, 1909, and as the supply of gipsy moth caterpillars was very limited at that time they were furnished with beefsteak for food. In each case the beetles fed on it for about a week, but selected caterpillars in preference whenever they were available. At the end of a week they seemed to become tired of steak and seldom fed on it. These observations show that this species will probably eat raw meat to a limited extent if forced to do so by hunger, but that caterpillars are always preferred and selected for food whenever they can be found.

Starvation Experiments with Calosoma Beetles.

May 26, 1910, 2 pairs of young Calosoma beetles that were pupæ in the fall of 1909 and 2 pairs of old Calosoma beetles that were received from Europe in the summer of 1909, and hibernated in cages in the laboratory yard, were placed in jars of earth, 1 pair in each, as soon as they came out of hibernation, to determine how long they could live without food.

Table XIII.—*Starvation experiment to determine the length of time the adult Calosoma sycophanta can live without food.*

Calosoma sycophanta.	Date emerged from hibernation.	Date male died.	Length of time male lived without food.	Date female died.	Length of time female lived without food.
	1910.	1910.		1910.	
Young pair	May 26	June 26	1 month	July 9	1 month 13 days.
Do	do	June 29	1 month 3 days	July 5	1 month 9 days.
Old pair	do	July 17	1 month 21 days	June 26	1 month.
Do	do	June 30	1 month 4 days	(1)	(1)

[1] This female, after living without food for 1 month and 21 days, was offered several full-grown gipsy moth caterpillars July 17, and ate 2 in 10 minutes. The next day a male was added, copulation was attempted several times, but without satisfactory results. The female died July 30 without depositing eggs. During the 12 days the pair were in the jar 33 sixth-stage gipsy moth caterpillars were eaten.

The beetles in the above experiments remained a portion of the time under the earth during the first two weeks, but from that time until they died were always to be seen on the surface at any hour during the day.

Table XIII shows that the Calosoma beetles can survive for a month without food, and under natural conditions in the field, where more or less moisture is present, the length of time would no doubt be increased. Apparently old beetles can withstand starvation better than young beetles, and males appear to die sooner than females, under these conditions, but several exceptions are to be noted in the table. The number of specimens under consideration is not large enough to give more than a general idea of the hardy nature of this species.

A field colony of Calosoma beetles was liberated in 1907 with the idea of testing their ability to survive on a very limited food supply. On August 28, 50 specimens, 25 of each sex, were liberated in woodland in Peabody, Mass. These beetles had been received from Europe during the month and had been supplied with very little food since they arrived. At the date of liberation there were no gipsy moth caterpillars in the field and very few pupæ. Occasionally a native caterpillar would be seen, but they were rare in the vicinity of the colony. Under these conditions it appeared possible to make a thorough test.

The colony was examined the next spring and summer. On July 8 a Calosoma larva was found, showing that reproduction had taken place. This would indicate that the species can survive under very unfavorable conditions.

Assembling Experiments.

In the summer of 1910 it seemed desirable to carry on a few experiments to determine, if possible, the distance that the male Calosoma beetles are attracted by the females, and for this purpose a cage was set up in the salt marshes between Lynn and Revere, Mass. This cage (fig. 20) was about 10 inches square and 12 inches high. The sides were covered with mosquito netting and underneath a narrow board which extended around the cage, and which was beveled on the underside, was stretched a thin sheet of rubber, which was attached in such a way that beetles from the outside could gain admission but could not escape. Within this cage was placed a wire cylinder containing both old and young females which had just emerged from hibernation.

June 13, 1910, this cage trap was set up in the marsh at a point one-half mile or more distant from any trees. It was attached to a pole about 8 feet high, and in the inner cage were 2 young and 2 old

females, with plenty of gipsy moth caterpillars for food. Beetles of this species were known to be present in the nearest wooded areas.

The trap was visited every three or four days until July 4, to see if males had been caught, and to supply food to the females. It was then visited about every ten days, until the middle of August, when it was removed. No males were caught during the experiment.

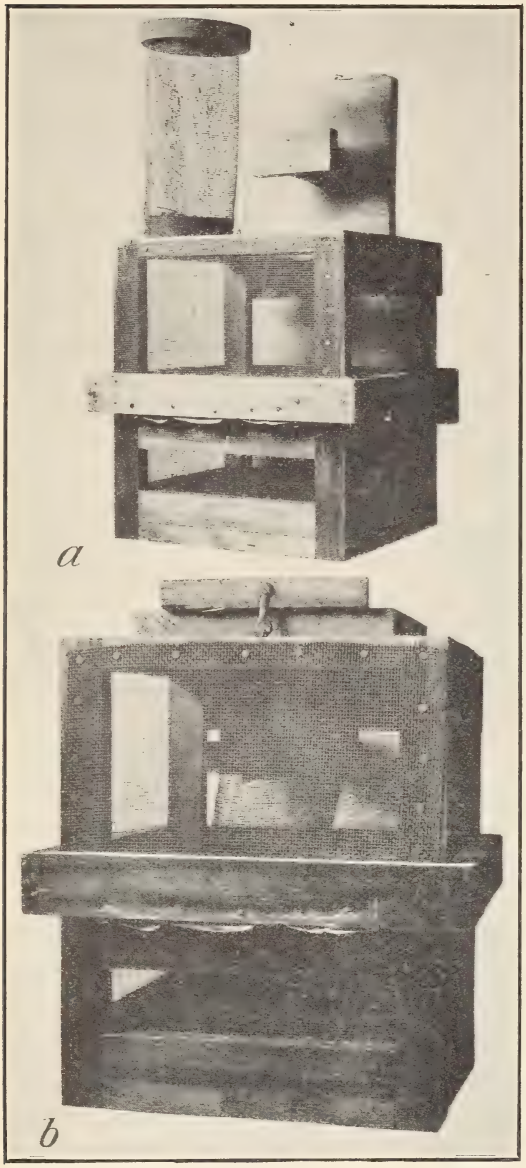


FIG. 20.—Assembling cage: *a*, Showing inner cage removed; *b*, cage ready for use. (Original.)

Another experiment, using the same kind of a trap, was begun at Wilmington, Mass., June 15, 1910. No specimens of *sycophanta* were known to be present within 2 miles of the point where the trap was placed. Four young and two old female beetles were put into the cage, and it was set up in a pine tree 45 feet from the ground. (See Pl. VIII.)

Marked males were then liberated at distances of one-half mile and 1 mile, respectively, north, south, east, and west of the trap, 1 old and 6 young beetles being released at each of the eight stations.

None of the males or females in this experiment had had an opportunity to come into contact with the opposite sex. This trap was examined every three or four days until the middle of July, and then at less frequent intervals, but no males were caught. On August 11 the trap was removed.

Only negative results were secured from these experiments. It is probable that the tests should have been started earlier in June.

Copulation.

After emerging from hibernation and feeding for a few days the beetles copulate, and egg laying is begun by the females. It is necessary for them to be mated with the males several times during the season, or a large percentage of infertile eggs will be laid. The record of a pair of beetles which were kept in a jar for the third summer is interesting as it gives data on the frequency of copulation of this species. The jar was examined once or twice a day when feeding records or other notes were being made. The pair was found *in coitu* June 27, 29, 30, July 8, 9, 10, 14, 15, 17, 18, 19, 20, and 26. They must have copulated at other times, because fertile eggs were laid on the date of the first copulation noted. The female deposited 274 fertile eggs during the summer. Old beetles show a greater desire to reproduce than young specimens.

In several cases females have been observed to copulate late in the summer, and no eggs were deposited thereafter. In each of these instances when the females were isolated in the spring without a male no fertile eggs were deposited until after a male was added and copulation took place. This indicates that the females can not be impregnated in the fall and lay fertile eggs the following season without further mating.

Reproduction.

The highest number of eggs laid in a single season by a female was 653. The next highest number recorded is 514. These records are far above the average, as is shown in the following table:

Table XIV.—*Average number of eggs laid by females of Calosoma sycophanta during 1908–1910.*

Year.	Females ovipositing.	Females not ovipositing.	Total females.	Number of eggs.	Average for females ovipositing.	Average for all females.
1908	20	4	24	1,662	83	69
1909	52	23	75	8,115	156	108
1910	72	26	98	8,720	121	89

The data for 1909 and 1910 are probably the most valuable, as a larger number of specimens was under observation and fewer experiments had to be conducted with material taken direct from European shipments.

It will be noted that nearly one-third of the females did not deposit eggs, and it should be stated that most of these were young beetles.

The data secured from observations made in field colonies indicate that in many of these where beetle larvæ were liberated it has been possible to find excellent reproduction the next season. It is probable that under natural conditions the average number of eggs laid by all female beetles in the field, regardless of age, will be about 100.

Young beetles do not lay as many eggs the first season as those beetles that are a year older; in fact it appears that a certain proportion of the young females does not oviposit at all the first season.

Table XV gives the results of a series of experiments carried on during the summer of 1910. It shows the difference in the egg-laying habits between the young and the old beetles and indicates the relation between active oviposition and food consumption.

TABLE XV.—*Difference in the egg-laying habits between young and old beetles of Calosoma sycophanta and relation between active oviposition and food consumption, 1910.*

No.	Caterpillars eaten.	Larvæ produced.	No.	Caterpillars eaten.	Larvæ produced.
Young beetles:			Old beetles:		
4804	241	61	4808	305	191
4805	174	0	4809	289	44
4806	346	31	4810	290	317
4807	95	0	4811	328	97
Average	214	23	Average	303	162

It will be noted that the old Calosoma beetles ate more gipsy-moth caterpillars and laid many more eggs than the young female beetles, 50 per cent of which did not reproduce. The following year these beetles will oviposit freely, as has been repeatedly shown in the previous work.

In order to ascertain whether any difference would result in breeding old males with young females and vice versa, 4 pairs of beetles were tested and the results are given in the following table:

TABLE XVI.—*Results of breeding Calosoma sycophanta: (1) Old males and young females; and (2) young males and old females.*

Pair No.	Caterpillars eaten.	Larvæ produced.	Pair No.	Caterpillars eaten.	Larvæ produced.
Old males, young females:			Young males, old females:		
4812	216	0	4814	461	155
4813	188	0	4815	230	[1]

[1] Eggs laid, but did not hatch.

The results shown in Table XVI should not be considered as conclusive owing to the small numbers of beetles used. It has occasionally been observed that young females reproduce when placed in jars with old males, and that the old females when kept in captivity with young males sometimes fail to do so.

ASSEMBLING CAGE FOR CALOSOMA BEETLES IN PINE TREE.

Arrow indicates position. (Original.)

It is evident, however, that greater reproduction takes place with old female beetles than with young ones, whether they are attended by young males or old males.

Some curious results of rearing experiments are given in Tables XVII and XVIII, which were prepared to show the length of life of adults of this species. Apparently it is the habit of these beetles to oviposit sparingly the first summer and freely during the second season. If conditions are very favorable the first year, a considerable number of eggs may be laid, while if they are unfavorable oviposition is postponed to the second or third summer as the case may be. It sometimes happens that eggs are laid the first and third summers, but not during the second; at any rate each female will lay about the same number of eggs, but the time when they are deposited varies greatly.

The data secured from field colonies bear out these facts. Two-thirds of the larval colonies have shown some reproduction the year following the planting, but in most cases the rate was very small, indicating that only a small proportion of the females laid eggs. By comparing the number of molted larval skins found in an adult colony in Wellesley, Mass., in 1908, and those secured in the larval colonies the year following their planting, it appears that the adult colony of old beetles reproduced thirteen times as rapidly as did the larval colonies during the year following their liberation. This may be explained in part by the greater tendency of the young beetles to disperse owing to scarcity of food or other natural causes, but it is evident that they reproduce much more slowly. The jar records indicate (see Table XV) that the old beetles multiply seven times as fast as young ones and an average in the field of 10 to 1 in favor of the old beetles would probably be about right.

Polygamy.

It has often been observed that females mate with the males several times during the summer and it is probable that this is necessary in order to insure the fertility of all the eggs.

Nearly every year several jars have been kept under observation where a single male was confined with 2 females and no cases have been noted where infertile eggs were deposited. In the summer of 1908 a record was kept of two jars, each containing a male and 3 female beetles. The insects fed voraciously and at the close of the season 306 eggs had been laid in one jar and 618 eggs in the other one, all of which hatched.

The average for each female in the first jar was 102 eggs and in the second 206 eggs, both of which are above the normal.

Although it is not known positively that each female in these jars laid eggs, it is probable that this was the case, owing to the large

number deposited, and if this supposition be true it indicates that a vigorous male beetle can successfully fertilize three females during the season and possibly more.

The Effect on Egg Deposition of Removing Beetles from Hibernation.

In March and April, 1908, cages containing several pairs of beetles were removed and brought to the laboratory and kept in a heated room. These beetles began laying eggs slightly earlier than those that emerged from hibernation normally, and most of them finished ovipositing by the 1st of July. The number laid was far below the average that is usually deposited by normal beetles and many of the specimens died earlier in the summer than is usually the case.

Effect of Cold Storage on Egg Deposition.

Several pairs of beetles were kept in cold storage during the winter of 1908–9. They were placed in the cold room soon after they developed from the pupæ and were removed March 16 and May 11, 1909. Very few of these laid eggs during the summer and most of them went into hibernation again the following winter. The number of larvæ produced the first year was far below the number secured from beetles of the same age that were allowed to emerge from hibernation at the normal time. In the case of old beetles the difference in the number of eggs deposited was not noticeable unless the beetles were kept in the cold room much longer than they would remain in hibernation under natural conditions.

Relation of Size of Beetles to Reproduction.

Among the specimens imported there is always considerable variation in size, and this is also true, possibly to a greater extent, with the specimens reared.

In order to determine whether differences in size had any special effect on the number of eggs deposited, measurements were made of a large number of the breeders during the summer of 1909.

Both sexes were measured, and in order to secure some standard to show the average size of each sex, four measurements were taken as follows:

(1) Length from anterior edge of thorax to tip of elytra.

(2) Length of elytra.

(3) Width of elytra at humeral angles.

(4) Length (ventral) of abdomen from between posterior coxal cavities to tip.

These measurements were added together and divided by 4 to get the average.

The egg records of 26 females are given herewith, the beetles being rated as large or small, those having average measurements that ranged above the general average being placed in the former class, and those below in the latter.

	Number.	Eggs laid.	Average of each.
Large females	15	3,848	256.5
Small females	11	1,846	168

This indicates that more eggs are normally developed by large females than by small ones.

It was desirable to determine, however, if the size of the males had any relation to the number of eggs produced, for if this were true the reliability of the data above given might be open to question.

Accordingly, typical data were secured from 9 males and 9 females which had been mated according to size, and are as follows:

	Eggs deposited.	Total.	Average per female.
Large male and large female	496 208	704	352
Small male and large female	200 342	542	271
Small male and small female	189 175	364	182
Large male and small female	134 207 85	426	142

This indicates conclusively that the size of the males is not an important factor relative to the number of eggs that the females will produce, and although there is quite a wide variation in the number of eggs laid by either large or small females, it demonstrates that large females will lay more eggs even when mated with a small male.

Sexes of Beetles Reared.

In order to determine the proportion of the different sexes of *C. sycophanta* reared from eggs laid, a careful record was kept of the sexes of the beetles that emerged in the spring of 1909 and 1910.

Of 71 beetles that were secured 39 were males and 32 were females (1909).

Of 512 beetles that were secured 261 were males and 251 were females (1910).

This indicates that under laboratory conditions practically the same number of each sex is reared.

Experiments in Crossbreeding Calosoma sycophanta and C. scrutator.

During the summer of 1910, Mr. Collins conducted several experiments to determine whether these two species would interbreed. The beetles are of nearly the same size and it seemed worth while to determine whether this would occur in the field.

June 20, 1910, one male *C. sycophanta,* received from Europe in 1909, was placed in a jar with a female *C. scrutator* which was collected in Washington, D. C., in 1909, and hibernated here the following winter. The male emerged from hibernation June 1 and the female June 5. June 21, 8.30 a. m., Mr. Culver noted that the pair had been attempting copulation for the last half hour. At 8.40 a. m. the male succeeded in his attempt at copulation and remained *in coitu* until 8.43. June 22, 2.48 p. m., Mr. Culver again observed the pair in copulation, and watched them for 7 minutes before they parted. June 23, 1 small egg was found, and on June 25 several eggs were noted in the jar. July 12, none of the eggs had hatched. Jar cleaned out. July 25, the male *sycophanta* was removed from the jar, and a male *scrutator* added instead. July 29, female *scrutator* died. No eggs were laid after the male *scrutator* was added.

Another experiment was conducted as follows: June 16, 1910, a female *sycophanta* emerged from hibernation. The cage was dug up on June 23, but no male was found. The pair were pupæ in the fall of 1908 and the female did not reproduce in 1909. June 23, a male *scrutator* was added which was collected at Onset, Mass., August 3, 1909, and brought to the laboratory. This male was kept in a jar with one female which produced 22 larvæ that year. Infertile eggs were seen in the jar containing the female *sycophanta* on the date the male was added, but the latter paid no attention to the female. June 27, infertile eggs in jar; jar changed. June 28, infertile eggs in jar; jar not changed. June 29, infertile eggs in jar; jar changed. June 30, 2 p. m., the male attempted copulation with female *sycophanta* three times but was unsuccessful, although the latter stood quietly and attempted to facilitate the operation as much as possible. July 1, 2, 3, 4, and 8, eggs on surface; jar changed. July 9, male *scrutator* died. Male *sycophanta* added, copulation took place immediately, and on July 14 larvæ hatched from the eggs deposited in the jar.

In the above experiments with the two species, copulation was attempted and unions effected apparently with difficulty, but all of the eggs were infertile.

Habits of Flight.

Few notes have been secured on the flying ability of this species. In the colonies the beetles have been frequently seen running about or climbing the trees, and they often drop from the branches to the ground without making any effort to fly.

Specimens confined in cages or jars have been observed to vibrate the wings rapidly. This is usually done soon after the beetles emerge from hibernation or toward evening.

A large cage of the native species, *C. scrutator,* was kept under observation one evening in June, and after twilight the beetles flew about the cage freely. This habit is well developed in this species, as the beetles are frequently taken at electric lights at night, in localities where they are abundant.

Apparently *sycophanta* must have the ability to fly, or the dispersion of the species in the field could not have been so rapid as is shown later in this report.[1]

Attraction of the Adults to Light.

As has been already noted, *C. scrutator* is frequently captured at electric lights. This does not often happen in New England, as the species is comparatively rare, but at Washington, D. C., and farther south, specimens can be commonly secured at arc lights during May and June.

Calosoma frigidum has this habit to some extent, as 2 males were captured at light traps at Reading, Mass., June 22, 1910.

Several observations have been made at electric arc lights located near colonies of *C. sycophanta,* but thus far no evidence has been secured which indicates that the beetles are subject to this attraction. Lights near a strong field colony at Oak Island, Revere, Mass., have been under observation when time permitted. No reports have been received from any of the field men that the beetles have been found at lights.

Drowning Experiments with Beetles.

March 17, 1910, cages containing frozen earth were dug up, and 2 male beetles were removed from their cavities and put in a jar of water. At 11 a. m. the jar was placed in the laboratory ice chest and kept at a temperature of 39 degrees F. Some pieces of cloth and two small blocks of wood were put in the jar with the intention of keeping the beetles submerged, but at 5.58 p. m., when an examination was made, both beetles were found swimming about in the water. They were again submerged by placing a quantity of blotting paper inside of the jar, but on the following morning they had succeeded in making their way to the surface. A wooden float was then constructed which was placed in the jar in such a manner as to keep the insects under water. They were kept in this position 4 days, although every 12 hours they were taken out and examined

[1] During the last few days of May and the first part of June, 1911, both sexes of *sycophanta* were observed to fly freely in the field. This was shortly after emergence from hibernation and the beetles probably do not fly freely later in the season.

to see if they showed signs of life. At the end of this period, as they were apparently dead, they were removed, but in less than an hour they revived sufficiently to begin feeding on cutworms.

This experiment shows that beetles of this species can live for at least 4 days and probably longer, if submerged in water a few degrees above the freezing point.

March 17, 1910, several small wire cages, used for feeding larvæ, each of which contained a newly formed beetle, were dug up and submerged in a tub of water to see if the insects would survive this treatment. There were several inches of frost on the top of each cage, and the temperature of the water was about 39° F. March 18, at 8 a. m., 1 female had emerged and was clinging to the wire just above the water. An examination of the earth in this cage showed that the hibernation cavity was about 6 inches deep and as soon as it thawed out the insect made its way to the surface of the water.

Another cage was examined after it had been submerged 24 hours and a living beetle was found 3½ inches below the surface of the earth. The cage was replaced and removed later in the day and it was found that the beetle had worked its way to a point a half inch below the surface of the earth. It appeared dead but on removal soon revived.

At the end of 48 hours another cage was examined, and a live beetle found 3½ inches below the surface of the earth. This cage was replaced and on the following morning after it had been submerged for 2½ days the beetle was found on the surface of the water.

The last cage was opened at the end of 4 days, and an active female was found in the earth which was now very compact. The beetle was replaced in the mud and the cage submerged, but at 3.10 p. m. came to the surface of the water after having remained beneath it 4 days and 2 hours.

These experiments indicate that this species is able to withstand excessive amounts of moisture and that in the spring when lowlands are flooded the majority of the insects will survive, apparently without serious inconvenience.

On March 21 a female Calosoma beetle that had been submerged for 4 days and 2 hours was placed in a tub of water and floated about on the surface. It seemed desirable to ascertain how long the insect would remain alive and float when the water was maintained at about 39° F., and also whether it was able to make any progress in swimming. During the first hour and fifteen minutes the insect swam a distance of 22 inches. It rested on the water very easily, less than one-half of the body being submerged. The legs were moved continually, but its progress was very slow. This beetle remained in the tub of water 15 days and at the end of that period was removed for dead. In a few hours it revived and began feeding, and was used later in the summer in rearing experiments. This shows that in the

spring beetles of this species might survive several days if they should fall into ponds, and that they would probably float with the currents and might be distributed quite a long distance in this way, especially if they fell into streams or rivers.

Length of Life of Beetles.

Unlike most species of insects, such beetles of the genus Calosoma as there has been an opportunity to study are, as a rule, able to survive two winters and carry on active warfare against caterpillar life during two summers.

With species whose length of life extends over such a long period it is difficult to secure normal data if they are closely confined, and although the laboratory experiments show that *Calosoma sycophanta* usually hibernates two winters and sometimes more, it is probable that under normal field conditions even greater length of life could be reasonably expected. An abundant food supply naturally stimulates the activities and reproductive capacity of the species, and where such conditions prevail, the insects exhaust themselves more rapidly, and the length of life of the adult is therefore somewhat curtailed. Such evidence as is at hand seems to show that if for any reason the food supply is scanty the majority of the beetles are able to survive, although their activities and rate of reproduction are materially decreased.

This bears out the observations which have been made at different times on native species of Calosoma which have been found very abundant during local caterpillar outbreaks, although previously they were considered somewhat rare.

The tables which follow give a summary of the data secured on the length of life of adults fed in captivity at the laboratory. Specimens received from Europe enter into this computation to some extent, but of course it is impossible to determine with any degree of accuracy the length of life of such insects, as their previous history is unknown.

A record is given of the length of life of seven examples, 3 males and 4 females. These, with several others, pupated in the fall of 1907, but the others died, chiefly because unsuitable hibernation quarters were furnished during the first winter.

Of the 4 females noted above, all of which were supplied with males during the summer of 1908 and 1909, 1 fed during the summer of 1908, laid no eggs, and died in hibernation during the winter of 1908–9; 2 fed during the summers of 1908 and 1909, laid eggs the latter summer, and died August 10 and 26, 1909. The remaining female fed during the summers of 1908, 1909, and 1910, laid eggs the first and third summers, hibernated three winters, and died August 1, 1910. Of the 3 males, all of which were placed in jars with

females each summer, 1 fed during the summer of 1908 and died in hibernation during the winter, while the other 2 fed in 1908 and 1909 and died in hibernation cages during the winter of 1909–10.

To summarize, 1 male and 1 female lived one summer and died in hibernation; 2 females died at the end of the second summer; 2 males lived two summers and died in hibernation the third winter; and 1 female lived three summers and hibernated three winters.

The record of a female received from Europe in July, 1907, is of interest as it shows what may happen in nature if the conditions are favorable. This female was kept in a jar with a male after receipt, but laid no eggs and went into hibernation in the fall. During the following summer she was isolated in a jar containing earth and supplied with food. The beetle survived hibernation and many infertile eggs were deposited during the winter of 1908–9. A male was supplied during the summer of 1909, during which time 106 fertile eggs were deposited, and the female died July 20.

From the time of receipt until the date of death 2 years and 11 months elapsed, and this insect must have spent one winter in hibernation in Europe and perhaps more before being collected for shipment. In other words, the insect must have lived at least three summers and passed three winters in hibernation.

Among the beetles received from Europe in the summer of 1908 were 3 pairs from which were secured the following interesting records concerning length of life.

TABLE XVII.—*Longevity of 3 pairs of Calosoma sycophanta received from Europe during the summer of 1908.*

No.	Male.	Female.	Eggs laid in—			Remarks.
			1908	1909	1910	
1513	1	1	0	0	238	Female died Aug. 8, 1910.
1592H	2	2	0	0	392	Females died July 25 and Aug. 13, 1910.

The females in this table failed to lay eggs until the second summer after receipt, and as soon as this was done they died. The length of life in each case was at least 3 full years. The imported males did not live so long, but their age at the time of receipt was unknown.

The table which follows gives data on the length of life of beetles which were reared in the summer of 1908. Each experiment was closed as soon as the female died, and in case the male died another specimen of the same age was added; hence more males than females are accounted for in the table.

TABLE XVIII.—*Longevity of 10 pairs of Calosoma sycophanta reared during the summer of 1908.*

No.	Male.	Female.	Eggs laid in—			Hibernation, 1910–11.	Remarks.
			1909	1910	1911		
1735	1	1	0	179	.....	Male entered Aug. 26, 1910, died.	Female died Aug. 16, 1910.
1736	1	1	0	18	26	Male and female entered July 28, 1910.	Male died in hibernation in 1909, replaced; beetles died Aug., 1911.
1743	1	1	38	0	53	Male and female entered July 26, 1910.	Female died July 31, 1911; male died Aug. 12, 1911.
1771	1	1	0	0	25	.....do.....	Female died July 6, 1911; male died July 31, 1911.
1775	1	1	0	0	142	.....do.....	Male died July 5, 1911; female died July 11, 1911.
2705	1	1	0	310	.....	.....	Female died Aug. 3, 1910; male died Sept. 2, 1910.
2728	1	1	0	345	.....	.....	Male died June 21, 1909, replaced; female died Aug. 14, 1910.
2729	.....	2	0	0	332	1 male and 2 females entered July 28, 1910; male died.	Two males added in 1909; one died July 8, 1910; one female died Aug., 1911.[2]
[1]2775	1	1	156	290	.....	.....	Female died July 10, 1910.

[1] Age of male in this experiment not recorded.
[2] Second female deposited eggs August 12, 1911.

Of the females listed in the table, 3 lived two summers, 5 died at the end of the third summer, and one is still living and ovipositing (Aug. 12, 1911). None of them laid eggs more than two seasons and some of them only one.

Of 10 males 4 died at the end of the first year or during the hibernation period following it, 2 died the second summer, and 4 the third summer.

These experiments indicate that, on the average, there is little difference in the length of life of the males and females. The latter commonly live two summers, and if the full number of eggs has not been deposited at the end of that time they continue to live until this result is accomplished, provided a sufficient food supply is available.

RELATION OF CALOSOMA SYCOPHANTA TO NATIVE SPECIES OF THE SAME GENUS.

The native species most closely resembling *Calosoma sycophanta* are *C. scrutator* Fab. and *C. willcoxi* Lec.

C. scrutator is more common in the central and southern part of the United States, and occurs somewhat rarely in the latitude of Boston, Mass., and farther north. It is a larger species than *C. sycophanta*; the green elytra are margined with a purplish band, and the thorax has a shiny copper-colored margin on all sides. These color markings distinguish it from *C. sycophanta*.

C. willcoxi is also a southern species but is occasionally found in Massachusetts and might be mistaken for a small specimen of *C. sycophanta*. It differs, however, in having color markings on the thorax and elytra similar to *C. scrutator*.

NATURAL ENEMIES OF CALOSOMA SYCOPHANTA.

During the summer of 1906 the remains of several dead Calosoma beetles were found under conditions which would indicate that the insects had been killed by some predatory enemy. In fact, one report reached the laboratory that a hairy woodpecker had been observed feeding on *C. sycophanta*. The locality where this observation was made was visited by Messrs. Titus and Mosher, and wing covers and fragments of legs and bodies of the species were found under a pine tree. Nearby was a nest of young crows, and it is probable that they were responsible for the trouble.

It is a well-known fact that crows feed on various species of carabid beetles, and specimens of native Calosoma have been found in the crops of these birds by various investigators, so that it would not be strange if they destroyed some of the imported ones.

In the fall of 1909 a report was received that birds, presumably crows, were destroying the beetles, as a number of fragments of the latter had been found on the ground in woodland near North Saugus, Mass. No absolute evidence was secured to prove that this was the case.

During the summer of 1910 Mr. H. S. Barber observed that several crows seemed to be loitering about in a locality where the larvæ of *C. sycophanta* were common under burlaps. None of the birds was seen in the act of feeding but the persistence which they exhibited in frequenting the locality aroused the suspicion that their mission was not a friendly one.

During the summer of 1907 all the dead Calosoma beetles that arrived in the shipments were isolated to determine whether parasites of any kind would develop, and of 584 beetles which were treated in this way, not one showed evidence of parasitic attack and no parasites were secured.

In rearing Calosoma beetles it is always necessary to guard against the accumulation of dead or decaying material. If such matter is permitted to accumulate in the rearing jars, the earth soon becomes infested with mites, which later attack the larvæ, or even the adult beetles. Probably in nature these insect enemies of the beetles do them no harm, as the conditions are not favorable for the increase of the mites.

During the summer of 1908 several jars became badly infested with a species of mite which was determined by Mr. Nathan Banks, of this bureau, as *Tyroglyphus armipes* Bks. The beetles were treated with carbon bisulphid, a small amount being applied with a brush to the underside of the thorax and abdomen, where the mites attach themselves most frequently.

The beetles survived the treatment perfectly, and after it had been repeated once or twice all the mites were destroyed. Several beetles

were freed of the mites by repeatedly scraping them with a small knife and brushing them with a small stiff brush.

Larvæ are more seriously injured by mites, and if attacked to any great extent will die either before or after pupating. This happened in several instances, and shows the necessity of keeping the jars as clean as possible.

In the spring of 1910 several young Calosoma beetles emerged from hibernation cages but died in a few days. An examination showed that the insides of the bodies were badly decomposed, and a large number of nematode worms was present. These beetles had been reared from larvæ late in the summer of 1909, and some of the lot were fed on gipsy moth pupæ that had been kept in cold storage and when removed were partially decomposed.

There was a considerable number of these pupæ in the cages late in the summer, and whether the nematode worms are able to feed upon them is not known. The death of the beetles may have been due to entirely different causes, and it is doubtful, judging from our experience, whether these insects are seriously injured by nematodes under field conditions.

A larva of *Carabus monilis* Fab. which was attacked, apparently, by the same trouble was sent to the Bureau of Plant Industry for determination, and on careful examination Dr. N. A. Cobb reported that two new species of nematode worms were present, viz, *Rhabdites calosomitis* and *R. diplopunctata*. He is inclined to believe that these worms were introduced from Europe with the beetles, and that they may be injurious. Inasmuch as the specimen attacked was one that was reared from eggs deposited at the laboratory, the chance of the parasite having been introduced from Europe is somewhat remote.

COLONIZATION OF CALOSOMA SYCOPHANTA.

As has been previously stated, the first importations of this beetle that arrived in good condition reached Massachusetts in the spring of 1906, and from the number of specimens received it was possible for Mr. Titus and Mr. Mosher to liberate several colonies that spring. The method followed was to put out from 30 to 50 Calosoma beetles in a locality where gipsy moth caterpillars were plentiful, and during the season six colonies were liberated, and 389 beetles were used for this purpose. No attempt was made to determine the sexes of the beetles liberated, and the colonies were placed in the towns of Saugus, Malden, Winchester, Burlington, and Lynnfield, Mass.

In the early summer of 1907 the beetle importations were cared for by Mr. Mosher, and one large colony of 331 specimens was liberated early in July in a badly infested woodland directly north of the old parasite laboratory at North Saugus. Later in the season, after the beetle work had been taken up by the writer and Mr. Collins, a few

other colonies were released. A stock of beetles was added to one of the Lynnfield colonies that had been liberated the previous year, and new colonies were put out at North Woburn and Peabody. The first lot of beetles placed in the North Woburn colony was on July 31, which was late in the season for effective work, and on August 2 more beetles were added to the colony, making a total of 50 males and 50 females for this liberation. The colony in Peabody consisted of 25 males and 25 females, which were released August 28, 1907.

In 1908 less than 700 live beetles were received from Europe; hence only a small number of adult colonies could be liberated. Experiments were carried on, however, in rearing the larvæ of this species at the laboratory, and as a result of this work it was possible to liberate 2,300 larvæ in field colonies during the breeding season. The general plan of liberation was to place all the colonies in badly infested sections, where plenty of food was available, and where the insects would be disturbed as little as possible by hand methods of suppressing the gipsy moth. Several colonies were liberated on estates, and in some cases active hand suppression methods were carried on in order to prevent defoliation by the gipsy moth caterpillars. In a few instances the trees were heavily sprayed, and, although this was not in accord with the intention when the plantings were made, it gave an opportunity for securing data on the ability of the insects to survive in case they were handicapped by spraying or other control measures. A few small colonies were also liberated in York County, Me.

In 1909 the work was continued along the same lines, but a larger number of larvæ was planted in field colonies. It might be added that a single colony was liberated in the fall of 1909 at Sandwich, N. H., the reason for this being that while no gipsy moths had been found in this town, the maple, beech, and other forest trees were suffering from a severe outbreak of *Heterocampa guttivitta* Walk., and it was thought advisable to release a colony for the purpose of determining whether the insects would be able to survive at that northern latitude and do any considerable amount of good in reducing the number of these caterpillars.

In 1910 this work was carried on in much the same way, but an effort was made to liberate colonies in towns where none had been previously placed, providing, of course, that suitable localities which were badly infested could be secured for the purpose. The result of this policy has been that practically all the towns in Essex, Middlesex, and Suffolk Counties, and a few in Norfolk, and a single one in Plymouth County, Mass., have been supplied with one or more colonies of the Calosoma beetle.

In the first larval colonies from 75 to 150 or 200 specimens were released, but since that year it has been the practice to put out not less than 200 specimens in a colony, unless some of the adult beetles are

liberated at the same time, and in this case the number of larvæ liberated is often reduced one-half.

The method of liberating field colonies of Calosoma beetles has depended on whether adults or larvæ were to be planted. When adults were used, they were taken to the area selected and scattered about among the badly infested trees.

More care was required in distributing larval colonies as it was necessary to pack the larvæ separately so that they would not injure each other before they were turned loose.

In 1909 the larvæ were placed separately in glass tubes, both ends of which were plugged with cotton. Before inserting the last plug, a

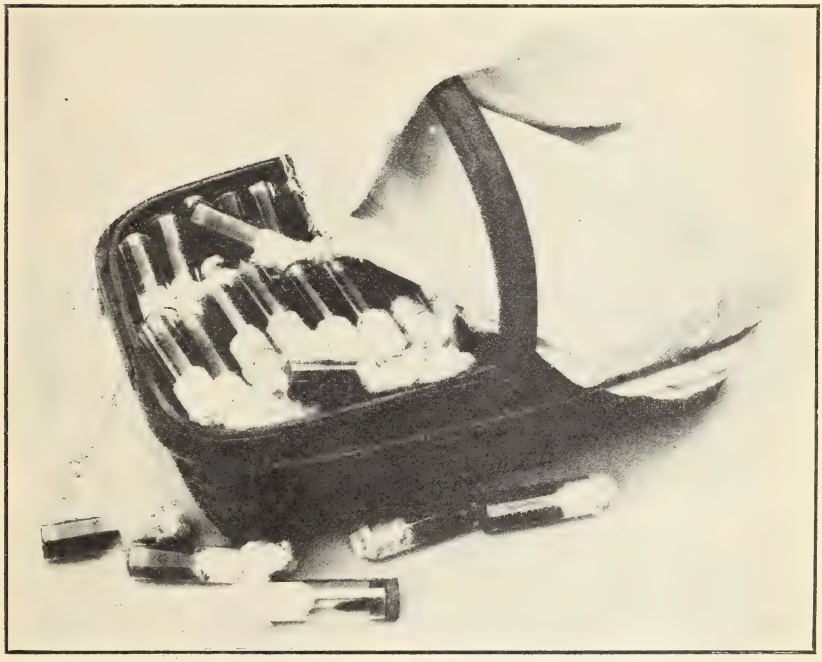


FIG. 21.—Two hundred tubes, each containing a larva of *Calosoma sycophanta*, ready for colonization. (Original.)

small amount of earth and sometimes a caterpillar or pupa was added with the beetle larva. These tubes were packed in a basket and taken to the place where the colony was to be liberated. (See fig. 21.) On arrival the contents were dumped at the base of infested trees and the tubes returned for refilling. Frequently the tubes became broken in handling and transit, and occasionally some of the larvæ made their way through the cotton plugs and escaped.

In 1910, a better device was used (fig. 22), which consisted of several units of wood in which was bored a double row of 10 holes, so that each block would accommodate 20 larvæ. The bottom of the block

was covered with fine-mesh copper wire to provide air, while on the top a sliding cover was arranged so that the holes could be closed as they were filled. Ten of these units were strapped together and were convenient to carry, and the colony (200 larvæ) which they contained could be liberated very rapidly by withdrawing the cover, inverting the unit, and giving it a sharp rap to shake out the insects.

Table XIX shows the number of living beetles imported and the number of beetles and larvæ colonized since the work began.

TABLE XIX.—*Number of living Calosoma sycophanta imported; and number of beetles and larvæ of Calosoma sycophanta colonized.*

Year.	Received.	Colonized from importations.	Reared and colonized.	
			Adults.	Larvæ.
1906	693	389	.....	.....
1907	967	578	.....	.....
1908	675	430	.....	2,300
1909	405	250	.....	6,100
1910	1,305	1,064	452	6,380
Total	4,045	2,711	452	14,780

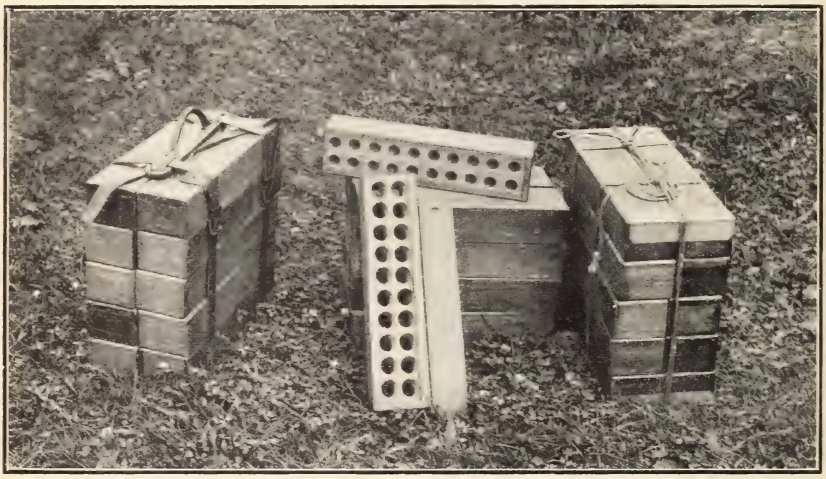


FIG. 22.—Three "sets," each containing 10 units, each unit holding 20 Calosoma larvæ in separate cells, so that each set contains 200 Calosoma larvæ or enough for a colony. (Original.)

During 1906 and 1907 the number of Calosoma beetles liberated was comparatively small and the following two years only a moderate number was colonized. It should be borne in mind that the present condition as regards the abundance and dispersion of this species in the field is due to the colonies liberated during the first two or three years rather than to those which have been planted since that time. Attention should be called to the fact that nearly as many beetles

were liberated during the summer of 1910 as had been released in all the previous years. This does not hold true in regard to the number of larvæ liberated.

Two years or more will be required before any accurate figures on increase in the colonies planted in 1910, or spread from them, can reasonably be expected. The information already given concerning the reproduction of new and old beetles bears directly on the conditions which exist in field colonies. If the beetles liberated in 1906 and 1907 reproduced at the normal rate, the progeny from these colonies should show far greater increase and dispersion than the beetles more recently liberated, and that this is the case will be brought out in the following pages. On the other hand, colonies consisting of larvæ, or beetles reared from larvæ, can not be expected to show any great increase for the first year or so, because young beetles ordinarily oviposit sparingly.

Owing to the fact that *Calosoma sycophanta* has been able to survive for a number of years under field conditions and that reproduction and dispersion have been going on at a satisfactory rate, as determined by observations made during the past four summers, it has been considered inadvisable to make further importations of this species, for the reason that if it is necessary to liberate more colonies aside from those that can be supplied from the material now being held at the laboratory, it should be possible to collect sufficient quantities in the field for the purpose.

METHODS OF SECURING DATA FROM FIELD COLONIES.

Since the work began it has been of the utmost importance to determine actual conditions in the field and to find out whether each introduced species was surviving and reproducing. During 1907 numerous visits were made to the colonies which had been liberated, but little of importance was found until about the middle of July, when Mr. L. S. Winchester, who had been employed for a few weeks to take up this particular work, found Calosoma beetle larvæ under the burlaps on trees where a colony had been planted in Burlington, Mass. This, of course, showed that the beetles had successfully hibernated during the winter and reproduced, and was a very encouraging sign. Later in the month several larvæ were found in the Saugus (Mass.) colony and a single larva was found in one of the colonies at Lynnfield, Mass., so that at the end of the season it was known definitely that three of the six colonies liberated in 1906 were well established in the field.

During the examination of the colony liberated by Mr. Mosher at North Saugus, Mass., in July, 1907, it was discovered, contrary to expectations, that the larvæ of this species climb the trees and feed upon the caterpillars and pupæ of the gipsy moth found on the trunks.

It also became apparent that many of the larvæ passed through the molting process on the trunks of trees, under burlaps, or among masses of caterpillars or pupæ of the gipsy moth. Later observations showed that this was a quite constant habit and in the years which followed it was made use of repeatedly as a means for determining the dispersion of this insect.

In 1908 plans were made to follow up the colonies more closely than had been done the previous year, and as the larvæ of this species had showed an inclination to secrete themselves under burlap bands where caterpillars were more or less abundant, it seemed advisable to burlap a number of trees in the center of each colony, so that conditions could be easily determined by occasional examinations of the burlaps during the summer. The plan was adopted of burlapping from 50 to 100 trees in each colony. The field work in these colonies was carried on by Mr. John V. Schaffner, jr., and Mr. F. V. Learoyd, and during the summer beetles or larvæ were found in all of the colonies except the one planted at Winchester. As it seemed desirable to continue this work after the larvæ had descended into the ground to pupate, and as very accurate results can be secured by searching for molted skins on the tree trunks, several weeks were devoted to this work. About the middle of July Mr. Learoyd was detailed to other work and Mr. Emory A. Proctor took up the field work in his place. As a result of these examinations it was also possible to trace the dispersion of the species in a limited way.

In 1909 the field examinations were carried on in the same manner by Messrs. Schaffner and Proctor, and late in the summer they were assisted by several other men employed at the laboratory. The results of the early summer inspection showed that the beetles existed in all of the colonies released in 1906, with the exception of one at Winchester. Of the total number of colonies placed in the field, 75 per cent were found to be reproducing. The results of the late summer inspection—that is, where the distribution of a species was determined by the presence of molted skins on the trees—is shown on the accompanying map (Pl. IX). This indicated a very encouraging increase and spread of the insect. The method of carrying on this work was to examine areas immediately outside of the beetle colonies which were badly infested with the gipsy moth, and if the molted skins were found, more territory was scouted until the outside limit of spread was reached.

During 1910 this work was continued, the same men having charge of the investigations in the field colonies. At the close of the work 80 per cent of all the colonies planted showed reproduction and much gratification was felt. Molted skins were found near the colony planted in Winchester in 1906, which indicates in all probability that some of the insects in that colony reproduced. The results of the

late summer scouting, in which work it was necessary to employ several assistants in order to cover the extensive territory which was examined, indicated that the beetles had spread over a much larger area than had been anticipated, and this is shown on the above-mentioned map (Pl. IX). In order to give an idea of the reproduction and dispersion under actual field conditions, a somewhat detailed account will be given of two colonies, namely, Saugus and Wellesley, Mass.

RECORD OF TWO FIELD COLONIES OF CALOSOMA BEETLES.

In July, 1907, Mr. Mosher liberated 331 beetles as soon as they were received from Europe in badly infested woodland near the old parasite laboratory at North Saugus, Mass. Larvæ of *sycophanta* were found later in the month and during the following year they were quite abundant. As there were plenty of gipsy moth caterpillars and pupæ for them to feed upon, it seemed desirable to determine the extent of spread and the amount of increase of the Calosoma beetles during the summer of 1908. In order to do this the woodland was examined thoroughly in August, and counts made of all the molted skins found. All the trees were climbed, and the rough bark, which was likely to harbor molted skins, was inspected, as were the masses of gipsy moth pupæ and the burlaps. Ninety-three first-stage and 294 second-stage molted skins were found in an area of about six acres, which seemed to represent the limit of spread of the species. That this was not the limit of spread, however, was definitely shown the next summer when larvæ and molted skins were found at intervals for more than half a mile in every direction.

In the fall of 1910 the colony was examined in the same manner as in 1908, and in the territory inspected the latter year 733 first-stage and 848 second-stage molted skins were found. This indicates that there had been an increase of the beetles in the center of the colony as well as a general dispersion of the species. A small block of trees adjoining this area was examined and molted skins were found in about the same relative numbers. A record of the dispersion from this colony could not be secured, because in 1909 it had merged with other colonies planted a mile or more distant.

In order to check up this data a careful scout was made, in the fall of 1908, of a colony at Wellesley Farms, Wellesley, Mass. The beetles that were placed in this colony, 105 males and 110 females, were received from Europe late in June, 1908, and were liberated July 1 of that year. The timber growth, which was chiefly oak, with trees of from 4 to 10 inches in diameter, had been burlapped, and two men were employed to destroy the gipsy moth caterpillars, as the infestation was bad. The beetles were liberated in two spots about 300 yards apart. The scouting in this colony consisted in

examining the burlaps and the trees as high up as a man could reach, as well as inspecting some of the stones or other material on the ground where the molted skins were likely to be found. Over an area of about 5 acres, 292 first-stage and 465 second-stage molted skins were found.

The following year no special inspection was made of the colony, but a general examination of the territory showed that the beetles had spread over about 2 square miles, chiefly to the westward.

In August, 1910, another careful examination was made similar to that of 1908, and in the same area that was examined the latter year 1,229 first-stage and 1,851 second-stage molted skins were found. The area over which the species had dispersed had also increased, so that evidences of the beetles were found over an area of 11.37 square miles. This colony was liberated in a region far away from other colonies, so that the spread did not come from other sources. A colony of larvæ was liberated in 1909 in Wayland and Weston, Mass., which area is now included, but it is improbable that these plantings spread to any great extent.

It is interesting to note the amount of handwork that was done in the colony. Although the trees had never been sprayed, the egg clusters had been treated each year with creosote. In the center of the colony the burlaps had not been turned, but in the remainder of the woodland they had been turned twice a week during the caterpillar season and the trees have never been defoliated.

COLONIES OF CALOSOMA LIBERATED IN MASSACHUSETTS.

The statement which follows gives a list of the towns and cities in which colonies of *Calosoma sycophanta* have been liberated, the number released, and a summary of the data which have been collected concerning the condition of the beetle colonies. This is given somewhat in detail, so that it may be of value to owners of property or residents in the several sections concerned.

Acton.—In West Acton, about 2½ miles from the railroad station, 200 larvæ of *Calosoma sycophanta* were liberated on July 15, 1910. The gipsy moth infestation in this town was not serious at that time, and the Calosoma beetles were placed in a woodland colony where the gipsy moth infestation was such that the beetles would secure enough food to develop and reproduce the next season.

Amesbury.—Calosoma larvæ to the number of 200 were liberated in the woodland off Haverhill Street, in Amesbury, on July 11, 1910. The gipsy moth caterpillars were present in sufficient numbers to furnish food for the development of these larvæ.

Andover.—At this point 50 male and 50 female Calosoma beetles that had just emerged from hibernation cages at the laboratory were released on June 4, 1910, in badly infested woodland off Rattlesnake Road. The colony was examined July 14, 1910, but no Calosoma beetles were found. Gipsy moth caterpillars and pupæ were very scarce, owing to the fact that the infestation was so bad earlier in the season that most of those in the center of the colony died from starvation or disease.

Arlington.—On July 13, 1910, 200 beetle larvæ were liberated in woodland off Appleton Street. The condition of infestation by the gipsy moth in this section was favorable for the survival of the colony.

Bedford.—On June 9, 1910, 50 male and 50 female Calosoma beetles that emerged from rearing cages at the laboratory were released in the woodland on Page Road, near the Lexington town line. Gipsy moth caterpillars were common, and a liberal food supply for the beetles was assured.

Beverly.—On July 17, 1909, 200 Calosoma larvæ were liberated in woodland, which had been partially stripped by the gipsy moth caterpillars, off Essex Avenue. Most of the gipsy moth larvæ were full grown at the time the planting was made, and some pupæ were present on the trees. This colony was examined July 18, 1910, and several beetle larvæ and molted skins were found on the trees. On August 29, this colony was scouted by Mr. Proctor, who reported that molted skins of the beetle larvæ were found on trees to a distance of 500 yards from the center of the colony, and, as he states that the number of egg-clusters present indicated that there would be plenty of food for the Calosoma larvæ the following year, it is probable that this colony will develop and spread rapidly.

Billerica.—On May 27, 1910, 50 male and 50 female beetles were liberated in badly infested woodland near Ranlett's Park, South Billerica. These beetles were reared at the laboratory and had just emerged from hibernation cages. The gipsy moth infestation was very serious in this section, although at this time the caterpillars were rather small. July 29 the locality where the beetles were released was scouted by Mr. Schaffner, but no molted skins of the Calosoma larvæ were found. Many of the gipsy moth caterpillars died from disease earlier in the summer.

On June 24 a planting was made in woodland off Sprague Street, North Billerica. Fourteen males and 28 females, most of them being beetles that were reared at the laboratory, were placed in this colony. Plenty of gipsy moth caterpillars were present for food.

Boston.—No Calosoma beetles have been liberated within the city limits. One of the Brookline colonies has spread over the line into Boston in the Forest Hills district.

Boxford.—On June 27, 1910, 200 Calosoma larvæ were liberated in badly infested woodland about 1 mile north of the railroad station. Gipsy moth caterpillars were present in large numbers, and the locality was favorable for the development and increase of the beetles.

Braintree.—On July 19, 1909, 200 Calosoma larvæ were liberated in infested woodland on Liberty Street, South Braintree. Gipsy moth caterpillars and pupæ were abundant, and conditions were favorable for the increase of the beetles. June 9, 1910, the colony was examined by Mr. Schaffner, and a single Calosoma beetle was found. October 1, 1910, the colony was again scouted, and 1 first-stage molted skin was found. The burlaps in and around this planting had been turned periodically during the summer, and the gipsy moth larvæ and pupæ had been crushed, which of course served to reduce the beetles' food supply. While this was being done, it is probable that the molted skins of the beetle, which are ordinarily found under the burlap, may have been brushed to the ground, so that it was impossible to determine to what extent the beetles in the colony had reproduced.

Brookline.—Several colonies were planted in Brookline in the summer of 1908, and in 1909 another colony was added.

On July 4, 1908, 100 beetle larvæ were liberated in badly infested woodland off Hammond Street. Another colony, containing 81 male and 64 female beetles, was liberated in infested woodland off Newton Street, and on July 8, 100 beetle larvæ were placed in badly infested woodland off South Street. The colony liberated in 1909 consisted of 200 beetle larvæ, which were placed in badly infested woodland off Heath Street.

Repeated examinations were made during the summer of 1909 of the colonies liberated in 1908, and in each one, except the Hammond Street colony, a record of definite and satisfactory reproduction was secured. Considerable spraying was done along Hammond Street, and as this colony was liberated near the road it is very probable that the beetles migrated after they emerged from the ground. On August 31 several molted skins were found 500 yards from the center of the colony, which indicates that the beetles had migrated. Some of the trees in and around this colony were cut during the previous winter, and this may have had a tendency to induce the insects to migrate to a more secluded place.

In 1910 all the colonies liberated in 1908 were found in good condition, and the Heath Street colony also showed satisfactory reproduction and spread.

It might be added that the conditions in this town were not ideal for the colonization of *Calosoma sycophanta*, as a large amount of spraying had been done, which so reduced the number of gipsy moth caterpillars that it is probable that in such areas the beetles find it necessary to migrate after the effect of spraying becomes noticeable on the caterpillars.

During the time that has elapsed since these colonies have been planted, the ones on Newton Street and South Street have joined, spreading over the very considerable area indicated on the map. The Heath Street colony has also joined with a colony liberated in 1908 on Newton Street in the city of Newton, near the Brookline line. The reproduction in the last mentioned colony will be considered under the colonies in the city of Newton.

Burlington.—On May 8, 1906, Mr. Titus released 40 beetles in badly infested woodland about 1 mile west of Cummingsville, in the town of Burlington. This colony was visited several times during the year, but no beetles were found. On July 16, 1907, Mr. L. S. Winchester began scouting operations in this colony, and continued the work for about 10 days. On July 17 he found several Calosoma larvæ, and continued to observe specimens working under burlaps almost every day that he visited the colony, but no beetles were seen. A total of about 50 larvæ was found by him.

In 1908 several examinations of the colony were made, and on July 17 a dead beetle and 3 molted skins were found. The gipsy moth caterpillars were very scarce in the center of this colony, and undoubtedly migration from this locality had taken place.

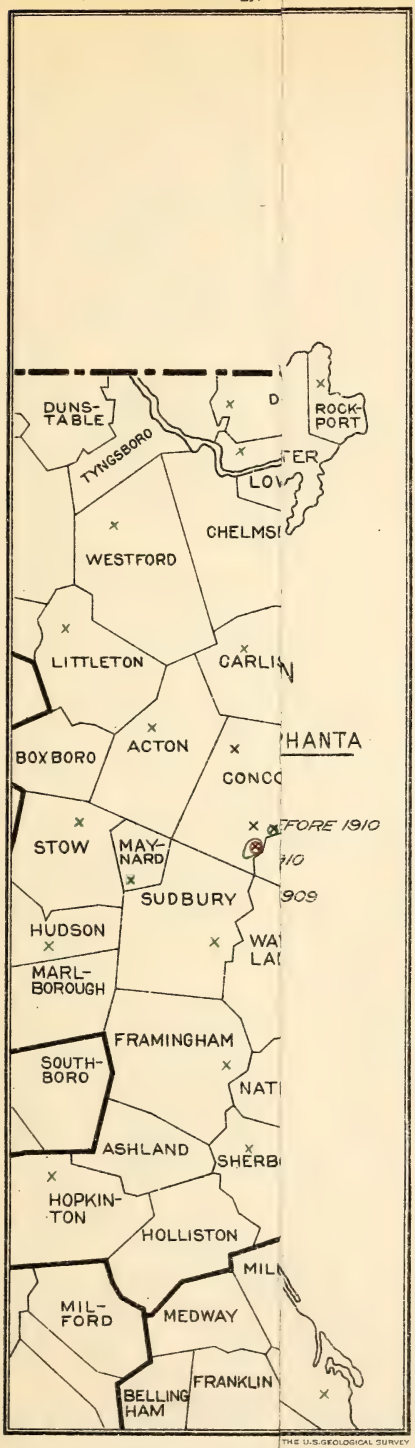
On June 21, 1909, 3 Calosoma beetles were found under burlaps, but no molted skins were discovered later in the season. On October 16 the woodland surrounding the colony was examined by Messrs. Schaffner and Proctor, and a few molted skins were found three-fourths of a mile from the colony. Later in the season more of the surrounding territory was examined, but no more evidence of the beetles was found.

In 1910 only a few molted skins were found, and these were a considerable distance from the center of the original colony. A large amount of territory was examined in this section of Burlington, without proving that the beetles were present. It might be said, however, that large areas of woodland in this region have been practically killed by the gipsy moth, and hence the infestation is not so bad as in some other sections where an abundance of foliage offers food for the caterpillars.

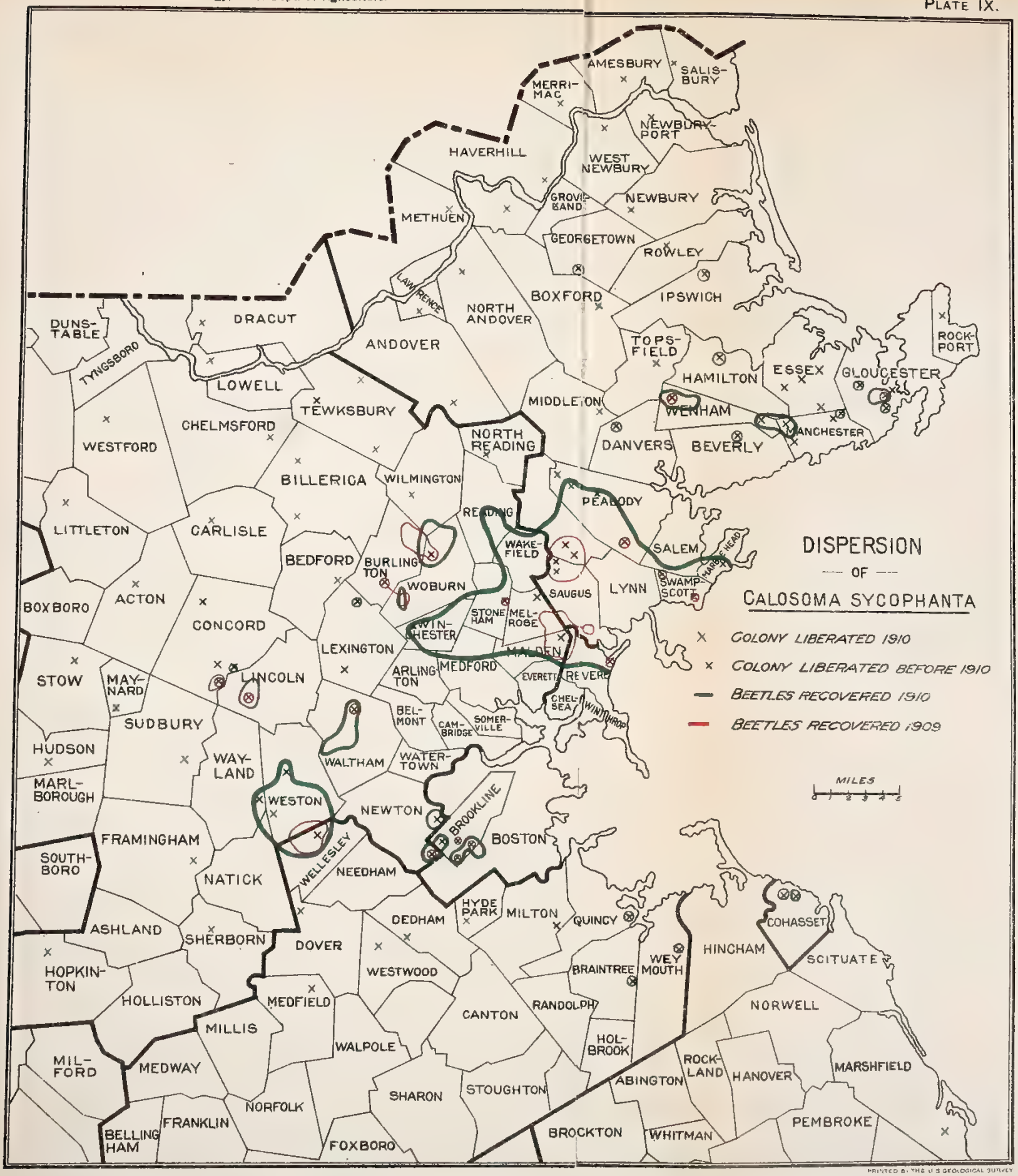
A colony that was liberated in North Woburn in 1907 had spread in 1909 to the northeastern part of Burlington, and in 1910 some beetles were found in this area.

Carlisle.—On June 22, 1910, 50 male and 50 female Calosoma beetles that had been received from Europe the previous day were liberated in badly infested woodland about 1 mile east of the Carlisle station.

Chelmsford.—On June 22, 1910, 50 male and 50 female beetles received from Europe the previous day were liberated in woodland where gipsy moth caterpillars were abundant. This colony was located near Billerica Road, about 1 mile from Chelmsford Center.



MAP OF EASTERN A.



MAP OF EASTERN MASSACHUSETTS, SHOWING DISPERSION OF THE CALOSOMA BEETLE, CALOSOMA SYCOPHANTA.

(From Howard and Fiske).

Cohasset.—On July 12, 1909, 200 Calosoma larvæ were released in badly infested woodland near the Jerusalem Road, and on July 27, 200 additional larvæ were liberated in woodland off Forest Avenue, about one-half mile from the colony previously mentioned. During the summer of 1910 the trees near where the first planting was made were badly defoliated. The colony was visited by Mr. Schaffner on July 1, but no beetles or larvæ were observed. Mr. Frank A. Bates, one of the agents employed by the State forester, informed me that he found several specimens of this beetle during that summer in this colony.

The colony off Forest Avenue was also visited by Mr. Schaffner on July 1. No beetles or larvæ were found, but the trees were not defoliated so badly as in the other colony. Examinations later in the season failed to reveal any traces of the beetle in this colony.

Concord.—On July 10, 1908, 25 male and 25 female beetles and 100 larvæ were released near Fairhaven Bay in infested woodland. Only a moderate amount of wooded area was infested, and most of the caterpillars had pupated at the time the liberation was made. June 28, 1909, a colony of 200 larvæ was liberated in the northwestern part of the town in badly infested woodland off Strawberry Hill Road. July 2, 1909, another colony of 200 larvæ was liberated near Walden Pond, in a moderately infested region. July 14, 1909, 200 larvæ were liberated in infested woodland off Sudbury Road.

During 1909 the Fairhaven colony was examined several times, and a few beetles and molted skins were found during the season.

Examinations made in 1910 indicate that the Fairhaven and Walden Pond colonies have survived, and that the beetles have spread a considerable distance from where the liberations were made. Only a few visits were made to the other two colonies, but no indications were found that the beetles had been working during the season.

Danvers.—On July 15, 1909, 300 Calosoma larvæ were liberated in woodland off Nichols Street, Danvers. The trees had been badly defoliated, and many of the caterpillars were dying from disease. A considerable number of gipsy moth pupæ was present. June 21, 1910, the colony was scouted by Mr. Proctor, and 2 male beetles were found. On September 17 another examination was made, and molted larval skins were found 200 yards from the center of the colony.

Dedham.—On July 9, 1910, 200 Calosoma larvæ were liberated in woodland off Sandy Valley Road.

Dover.—On July 2, 1910, 200 Calosoma larvæ were liberated in woodland off Pleasant Street, Dover.

Dracut.—On June 24, 1910, 50 male and 50 female Calosoma beetles were liberated in badly infested woodland near Lakeview Park.

Essex.—On July 7, 1909, 149 Calosoma larvæ were liberated in infested woodland near Wood Drive, near Chebacco Lake. July 22, 1909, 200 Calosoma larvæ were liberated in woodland near a bad gipsy moth infestation off Conomo Drive. July 24, 1909, 200 larvæ were liberated in woodland off the Old Essex Road, near the town line of Manchester and Essex. All of these colonies were examined during the summer of 1910. On June 14, 2 beetles were found in the last-mentioned colony, but in the others no adults or larval skins were secured.

Framingham.—On July 16, 1910, 200 Calosoma larvæ were liberated near Framingham Junction, in infested woodland.

Georgetown.—On July 17, 1909, 200 Calosoma larvæ were liberated in woodland near Baldpate station. The infestation was moderate and conditions were favorable for a colony. June 16, 1910, the colony was examined, but no beetles found. The woodland had been sprayed, but many gipsy moth and brown-tail moth caterpillars were present. July 5 examination was made in the territory immediately outside of the colony and two Calosoma larvæ were found. On September 19 another examination

was made in and around the colony. A few molted skins were found under burlaps, and also some 100 yards east of the original planting.

Gloucester.—On June 23, 1908, 75 Calosoma larvæ were released in a moderately infested woodland area about 1 mile east of the West Gloucester station. July 14, 100 larvæ were liberated in an infested woodland area half a mile east of the West Gloucester station, and on July 30, 100 more larvæ were placed in the woods a short distance from the point where the last-mentioned liberation was made.

These colonies were examined in 1909. Nothing was found in the first colony, but in the second, beetle larvæ were observed on July 10 and 16, and later in the year a considerable number of molted skins was found.

July 20, 1909, 200 Calosoma larvæ were liberated in woodland off the State Road in Magnolia, and on July 22, 200 were placed in a badly infested wooded area near Haskell's Pond.

In 1910 all these colonies were examined during the summer, and in the early fall the surrounding region was carefully scouted for molted skins. No indications of Calosoma beetles were found in or around the colony liberated 1 mile east of West Gloucester station.

In the colony liberated near the West Gloucester station a few beetles were noted during that summer. Later in the season molted skins were found 1 mile south and 1 mile west of the center of the colony.

Molted skins were also found in the colonies liberated near the State Road at Magnolia and at Haskell's Pond, which indicated that these plantings had survived and the beetles were increasing.

Groveland.—On July 5, 1910, 200 Calosoma larvæ were liberated in an infested wooded area located on a hill near the center of the town of Groveland.

Hamilton.—On July 14, 1909, a colony containing 60 male and 44 female beetles and 100 larvæ was liberated in infested woodland off Farm Road. June 1, 1910, 1 male beetle was found in this colony. Later in the summer examination showed that several molted skins were present in the colony and a few were also found 100 yards distant.

Haverhill.—On July 5, 1910, 200 Calosoma larvæ were liberated in badly infested woodland about 1 mile north of the Groveland Bridge. On July 6, 200 larvæ were released in woodland in Bradford, near the electric car line from Haverhill to Andover.

Hopkinton.—On July 7, 1910, 50 male and 50 female Calosoma beetles received from Europe were liberated in infested woodland in Hopkinton.

Hudson.—On July 7, 1910, 50 male and 50 female Calosoma beetles received from Europe the previous day were liberated in infested woodland on Priest's Hill.

Hyde Park.—On July 19, 1910, 200 Calosoma larvæ were liberated in woodland near the corner of West and Austin Streets.

Ipswich.—On July 17, 1909, 200 Calosoma larvæ were released in woodland off Rowley Road. July 16, 1910, a male beetle was found in this colony. Gipsy moth caterpillars were very abundant, and the trees were being stripped of foliage. A later examination, made on September 20, 1910, revealed the presence of a considerable number of molted skins of the Calosoma larvæ in this colony.

Lawrence.—On July 18, 1910, 200 Calosoma larvæ were liberated in woodland off Beacon Street, South Lawrence.

Lexington.—On July 3, 1908, 100 Calosoma larvæ were liberated in woodland near the State Road in Lexington. The trees on the opposite side of the street had been entirely defoliated by the gipsy moth caterpillars, and many of those in the area where the liberation was made were badly stripped. Gipsy moth caterpillars were very scarce, but some moth pupæ were present on the trees where the Calosoma larvæ had been released. The colony was examined several times during the summer of 1909. No trace of Calosoma beetles or their larvæ could be found. Gipsy moth caterpillars were rather scarce. Several examinations were also made during the

summer of 1910 with the same result. Early in the season fire ran through the woods and burned over the area where the liberation had been made.

July 16, 1909, 200 Calosoma larvæ were liberated on the east side of the town, in woodland, off Paint Mine Road. The colony was examined several times during the summer of 1910, but no beetles were found. On October 4 several molted skins were found 100 yards outside of the planting, and also a large number of gipsy moth pupæ that had been eaten by the Calosoma larvæ.

Lincoln.—On July 18, 1908, 100 Calosoma larvæ were liberated in infested woodland about 1 mile northwest of the railroad station. The colony was examined several times during 1909, but few beetle larvæ were found. Gipsy moth caterpillars were very abundant in a part of this colony, and some of the trees were stripped, and this caused the owners to have a portion of the area sprayed. The colony was inspected several times in the summer of 1910 and a few Calosoma beetles were found. In the fall a careful examination showed that the beetles had spread about three-fourths of a mile north and one-half a mile east of the planting. A number of molted larval skins was found throughout this area.

Littleton.—On July 15, 1910, 200 Calosoma larvæ were liberated in woodland about one-fourth of a mile from the railroad station. Gipsy moth caterpillars were common, but none of the trees had been stripped.

Lowell.—On July 18, 1910, 200 Calosoma larvæ were liberated in woodland near the Lowell General Hospital.

Lynn.—No beetle colonies have been planted in this city, and up to and including the year 1909 no evidence of the presence of this insect could be found, although several days were spent in making careful examinations in various sections of the Lynn woods. It was believed that the insects would make their first appearance in that part of the city, owing to the fact that several colonies had been liberated in Saugus and Lynnfield. In the summer of 1910, in several localities which had been visited the previous summer, beetles and larvæ were found. Later in the summer examinations were conducted for molted skins, and in some parts of the Lynn woods they were found abundantly. Molted skins were also found throughout the northern part of the city and in the residential section nearest the woods.

Lynnfield.—On July 7, 1906, 100 specimens of *Calosoma sycophanta* and 20 specimens of *Calosoma inquisitor* were placed by Messrs. Titus and Mosher in woodland near Broadway. This colony was visited several times during the summer of 1907, but no beetles or larvæ were found. In 1908 examinations on July 2 and July 8 resulted in the discovery of several larvæ in the center of the colony. Several visits were made in 1909 and a considerable number of beetles and larvæ was found during June and early July. Later examinations were made and it was found that the Calosoma had spread over a large area in the eastern part of the town. It had also spread north and west so that this colony had fused with another, which will now be mentioned. June 20, 1906, Mr. Titus liberated 118 beetles in a pine grove which was nearly surrounded by hardwood growth. The trees were badly infested by gipsy moth caterpillars, and although several examinations were made later in the season no Calosoma beetles or larvæ were found. July 31, 1907, a single larva was found by Mr. Collins, and on the same date 50 pairs of beetles were liberated a short distance from the point where the previous planting had been made. Several examinations were made during the summer of 1908, and 2 live Calosoma beetles were found on July 23. In 1909 the Calosoma beetles were more numerous, and the examination of the surrounding territory showed that this colony had fused with the one in Lynnfield, already mentioned, and specimens were also found west of the colony in the town of Saugus. Subsequent scouting showed that two colonies in Saugus, which are treated under that town, had spread to such an extent that they had joined with the Lynnfield colonies. In 1910 examinations were made late in the season and traces of the beetles were found throughout the southern part of the town as well as in adjoining towns, which will be mentioned later.

Malden.—On May 8, 1906, Mr. Titus liberated 40 specimens of *Calosoma sycophanta* in badly infested woodland in Malden near the Saugus-Melrose line. During June, on visiting the colony, he was able to find 2 beetles. This colony was examined in 1907, but no trace of the Calosoma beetles or larvæ was found, and although several examinations were made the next summer nothing was found until July 16. On that date 6 full-grown Calosoma larvæ and about 25 molted skins were collected, some of them being taken 100 feet from the point where the original liberation was made. In 1909, Calosoma beetles and larvæ were abundant in this colony and in the fall a careful examination was made of the surrounding territory. It was found that the insect had spread over a section of Malden known as the Maplewood district and as far south as the Linden station. The beetles were also found over a considerable area in the southeastern part of Melrose, and in Saugus in the vicinty of Cliftondale. Some specimens were found in a section of Revere not far from the center of the colony, known as Franklin Park. In 1910 examinations showed that this colony had spread over practically the whole northern half of the city of Malden and into the adjoining towns and cities.

Manchester.—On July 27, 1909, 150 Calosoma larvæ were liberated in woodland on School Street, about one-half mile from the Essex town line. July 24, 200 Calosoma larvæ were liberated in a badly infested area off School Street, one-half mile farther north. Examinations of these colonies made in 1910 showed that in the latter a few beetles were present, but none was found in the first colony. Infestation by the gipsy moth was less severe than the previous year, as a large number of the moth caterpillars died from disease.

June 7, 1909, 39 male and 34 female Calosoma beetles were liberated off Crooked Lane, in Manchester. July 10, 300 beetle larvæ were liberated north of the area previously mentioned and not far from the Wenham line. Examinations made during the summer of 1910 failed to indicate the presence of the beetles near the point where the adult colony was liberated. Molted skins were found, however, near the larval colony; some were in the town of Manchester, others in Hamilton, and still more in Wenham. It is probable that some of these beetles spread from the colony located in the eastern part of Wenham, which will be mentioned later.

Marblehead.—On July 9, 1908, 100 larvæ of *sycophanta* were liberated in Marblehead about one-half mile east of the Forest River station. On July 15 of the same year 100 more larvæ were added to this same colony. Plenty of gipsy moth caterpillars were present and the Calosoma colony appeared to be in a flourishing condition when it was examined about a week later. During the summer of 1909 several visits were made to the colony, but no Calosoma beetles or larvæ were found. On June 30, 1910, the owner of the property said that he had seen two "green beetles" in the woodland earlier in the season, which were undoubtedly specimens of *Calosoma sycophanta.* Later in the summer molted skins were found near the Forest River station. Some beetles evidently had survived in this colony, but many had either migrated to other places or else conditions were not as favorable as might be wished for the rapid increase of the species.

Marshfield.—On June 30, 1910, 200 Calosoma larvæ were liberated in infested woodland near Marshfield Center.

Maynard.—On July 25, 1910, 200 Calosoma larvæ were liberated in badly infested woodland. Only a small number of gipsy moth caterpillars was present, but pupæ were more abundant.

Medfield.—On July 2, 1910, 50 male and 50 female Calosoma beetles were liberated in infested woodland in Rocky Woods.

Medford.—No colonies of Calosoma beetles have been liberated in this town, but during the summer of 1910 indications of the presence of the beetles have been found throughout the northern part of the city.

Melrose.—On June 25, 1909, 100 Calosoma larvæ were liberated in the northeastern part of the city not far from the Saugus-Wakefield line. June 30, 100 larvæ were added

to this colony. Practically every section of this city was examined in 1913 and beetles were found in small numbers throughout the entire area. It is probable that only a few of these came from this colony. Large numbers must have migrated from the colonies in Saugus and Malden. In the northeast section of the Melrose Highlands district the beetles were quite common in the woodland during the summer, and it was usually possible to find one or more of the beetles or larvæ at work if careful search was made.

Merrimac.—On July 11, 1910, 200 Calosoma larvæ were liberated north of Main Street, in Nichols Woods.

Methuen.—On July 6, 1910, 200 Calosoma larvæ were liberated in infested woodland in the eastern part of the town not far from the Haverhill line.

Middleton.—On June 23, 1910, 50 male and 50 female Calosoma beetles, which had been received from Europe two days previous, were liberated in badly infested woodland off East Street.

Milton-Quincy.—On July 6, 1909, 200 Calosoma larvæ were liberated in infested woodland near Shawmut Spring in Cunningham Park. This colony was visited only once during the summer of 1910, and no beetles or larvæ were found. At the time of the examination many of the gipsy moth caterpillars were dying as the result of spraying or from disease.

Natick-Weston.—On July 22, 1910, 200 Calosoma larvæ were liberated in badly infested woodland on South Avenue near the Natick-Weston line. There were many gipsy moth egg clusters and some moths present, but only a few gipsy moth pupæ and caterpillars.

Newbury.—On July 8, 1910, 42 male and 46 female Calosoma beetles, which had been received from Europe two days previous, were liberated in badly infested woodland near the Byfield station.

Newburyport.—July 26, 1910, 200 Calosoma larvæ were liberated in woodland near the West Newbury line. Some gipsy moth larvæ and pupæ were present, but a large number of the moths had laid their eggs.

Newton.—On July 4, 1908, 100 Calosoma larvæ were liberated in woodland off Newton Street, about one-fourth of a mile from the Brookline line. July 6, 1909, 1 female beetle and 9 larvæ were found on trees in the center of this colony, and later in the season when the surrounding territory was scouted a large number of gipsy moth pupæ was found that had been destroyed by the beetles. June 24, 1910, an examination was made and beetles found in the colony. The trees had already been sprayed. Late in July the territory between this colony and the one of Heath Street, Brookline, was visited and molted skins found in different localities between the places where the original liberations were made.

June 30, 1909, 200 beetle larvæ were liberated in woodland off Langley Road, Newton Center, and on July 13, 200 more larvæ were placed in the same woods about one-half mile from the original colony. The territory where these liberations were made was examined several times during the summer of 1910, and both beetles and larvæ were found.

North Andover.—On June 16, 1910, 50 male and 50 female beetles which emerged from hibernation at the laboratory were liberated in badly infested woodland off Osgood Street.

North Reading.—On July 6, 1910, 200 Calosoma larvæ were liberated in woodland about one-half mile from the State road.

Peabody.—On August 28, 1907, 25 male and 25 female Calosoma beetles that were received from Europe in August were liberated in wooded area which was badly infested. All the gipsy moth adults had emerged at this time, and but few caterpillars of any kind were present to serve as food for the Calosoma beetles. Several examinations were made during the summer of 1908, and on July 8 a full-grown larva of *C. sycophanta* was found under burlap. In 1909 several beetles were found in the

colony, although the gipsy moth infestation was rather light, and an examination of the surrounding territory in August failed to show any indications of the Calosoma beetles or their larvæ.

July 2, 1909, 100 Calosoma larvæ were liberated in woodland off Birch Street, West Peabody. Several examinations were made during the summer of 1910, and a few molted skins were found outside of the colony.

July 3, 1909, 200 Calosoma larvæ were liberated off West Street near the West Peabody station. In the summer of 1910 many larvæ and molted skins were found.

June 23, 1910, 50 male and 50 female Calosoma beetles just received from Europe were liberated in badly infested woodland near the Middleton Paper Mills.

Quincy.—July 19, 1909, 200 beetle larvæ were liberated in a badly infested wooded area off South Street. Several examinations were made during the summer of 1910, and beetles and larvæ were found in abundance in and around where the colony was liberated.

Reading.—No colonies have been liberated in this town. Molted larval skins were found in the summer of 1910 in the southeastern and central parts of the town, having spread from the Saugus plantings.

Revere.—July 26, 1908, 100 Calosoma larvæ were liberated on Oak Island, and on July 27 100 additional larvæ were placed in this colony. These were liberated on the east side of the railroad track. On August 3 100 Calosoma larvæ were liberated on the extreme west edge of the wooded area. The colony has been visited each year, and beetles and larvæ have been found in moderate numbers.

Rowley.—On July 8, 1910, 200 Calosoma larvæ were liberated in infested woodland off the Newburyport Turnpike.

Rockport.—On July 13, 1910, 200 Calosoma larvæ were liberated in woodland in the rear of Manning Park.

Salem.—No colonies have been liberated in Salem, although a number of larvæ was released in Swampscott in 1908, not far from the Salem line. In 1910 an examination showed that the beetles had spread over the southern part of the city, the strip where they were found being about one-half mile in width.

Salisbury.—On July 11, 1910, 200 Calosoma larvæ were liberated in infested woodland in this town.

Saugus.—On May 6, 1906, Mr. Titus liberated 24 Calosoma beetles in woodland in North Saugus, and on June 26, 25 more were liberated in the same region. July, 1907, several larvæ were found in this colony, and in 1908 a few beetles were found.

July 3, 1907, Mr. Mosher liberated 228 Calosoma beetles in badly infested woodland directly north of the old gipsy moth laboratory at North Saugus, and on July 7, 103 more beetles were placed in this colony. Calosoma larvæ were found late in July, and in the summer of 1908 both beetles and larvæ were common in the center of the colony. This liberation was made about a mile from the one put out by Mr. Titus. In the summer of 1909 a careful inspection of territory showed that beetles were present in the area between the two colonies, and molted skins were found for a considerable distance surrounding each. The colony planted by Mr. Mosher had spread east and northward and fused with the Lynnfield colonies. It also had spread westward, as molted skins were found in woodland in the eastern part of the town of Wakefield. In 1910 the beetles were found in practically all parts of the town of Saugus.

Sherborn.—On July 2, 1910, 200 Calosoma larvæ were liberated in infested woodland off Main Street, Sherborn.

Stoneham.—On June 22, 1908, 75 Calosoma larvæ were liberated in woodland off Franklin Street, Stoneham. Examinations were made in this colony in 1909 and a few beetles were found. Several were also found in 1910. Later in the season a general inspection was made of the territory in Stoneham where gipsy moth caterpillars had been very abundant. Molted skins were found in the eastern and southern parts of the town.

Stow.—On July 7, 1910, 48 male and 38 female Calosoma beetles were liberated in badly infested woodland.

Sudbury.—On July 25, 1910, 200 Calosoma larvæ were liberated in badly infested woodland in East Sudbury. On this date very few gipsy moth caterpillars or pupæ were present. Most of the moths had emerged and several had laid their eggs.

Swampscott.—On June 26, 1908, 75 Calosoma larvæ were liberated in infested woodland off Danvers Street. On June 30 100 more larvæ were added to this colony. Examinations were made in 1909, and a few beetles were found in the colony. In 1910 no beetles or larvæ were seen in the center of the colony, but in the area outside where gipsy moth caterpillars were at all abundant, molted skins were found.

July 1, 1908, 100 Calosoma larvæ were liberated on high land north of the Ocean House. On July 6, 100 more larvæ were added to the colony. Examination was made in 1909, but no beetles or larvæ were found. During the summer of 1910 several larvæ and molted skins were found from one-half mile to a mile distant from the colony.

Tewksbury.—On August 12, 1908, 100 Calosoma larvæ were liberated in woodland where gipsy moth caterpillars had been present earlier in the season. At this date all the moths had emerged and deposited their eggs. Brown-tail moth caterpillars were hatching and feeding on foliage of some of the deciduous trees. This colony was examined in 1909 and 1910, but no Calosoma beetles or larvæ were found. The colony was liberated principally as an experiment to determine whether it was possible for any of the beetle larvæ to survive and develop upon such a limited food supply.

July 2, 1910, 50 male and 50 female Calosoma beetles were liberated in badly infested woodland off Shawsheen Avenue. July 14, 1910, 200 beetle larvæ were liberated near Prospect Hill in infested woodland.

Topsfield.—On July 8, 1910, 180 beetle larvæ were liberated in badly infested woodland off High Street.

Wakefield.—No beetles have been liberated in this town. In 1909 it was found that a small area along the eastern border had been stocked with beetles from the Saugus colonies, and in 1910 the beetles were found in various localities in practically every part of the town visited.

Waltham.—On August 7, 1908, 100 Calosoma larvæ were liberated in wood and brush land off Lake Street. At this date no gipsy moth caterpillars were present. A few small brown-tail moth larvæ were feeding and occasionally a native caterpillar would be found. The Calosoma larvæ were nearly full grown, all having molted the second time. This colony was examined in 1909, and no beetles or larvæ were found during the summer, but on September 2 a single molted skin was found under burlap near the center of the colony. June 1, 1910, a beetle was found in the center of the colony, and in July several larvæ were noted. The territory surrounding was scouted in August and September and a considerable number of molted skins was found in Prospect Park, some of these at a distance of 2 miles south of the colony.

Wayland.—On July 12, 1909, 200 Calosoma larvæ were liberated in infested woodland off Poor Farm Road. The colony was examined in 1910 and a few beetles and larvæ were found near where the original planting was made. In September molted skins were found about 200 yards outside the planting.

Wellesley.—On June 27, 1908, 36 male and 37 female Calosoma beetles were liberated in infested woodland near Wellesley Farms station. July 2 69 males and 81 females, taken from a shipment received from Europe June 29, were liberated in this same colony. In the fall of 1908 an examination of the trees in this colony was made and a large number of molted skins was found on the trunks and underneath the burlaps. In 1909 and 1910 both beetles and larvæ were found in the center of the colony. In 1909 the territory in the northern part of Wellesley and extending into the southern part of Weston, about 2 miles in length and 1 mile in width, was inhabited by this species. In 1910 this region was kept under observation, and late in the season areas

outside were thoroughly examined. It was found that the general direction of distribution had been toward the north and west, and territory shaped like an onion embracing the northern part of the town of Wellesley and the southern part of the town of Weston, and extending to a point beyond the Weston railroad station, showed marked evidences of the presence of this insect.

Wenham.—On June 27, 1908, 6 male and 6 female Calosoma beetles and 75 larvæ were liberated in badly infested woodland off Cherry Street. In 1909 this colony was examined and beetles and larvæ were found. Late fall examinations showed that they had dispersed over a relatively small area. In 1910 the entire western end of the town was examined, and beetles were found over an area of about one-half square mile.

July 14, 1909, 43 male and 30 female Calosoma beetles and 100 of their larvæ were liberated off Grapevine Road. The territory was examined in 1910, and beetles and larvæ were found outside the colony. Beetles and larvæ were also found in the towns of Hamilton and Manchester at a distance of one-half mile or more from where this colony was liberated.

Westford.—On June 24, 1910, 100 Calosoma larvæ were liberated in woodland in the northern part of the town, and on June 28 100 more larvæ were added to the colony.

Weston.—On June 24, 1909, 100 Calosoma larvæ were liberated in woodland near the railroad station, and on June 26 100 more larvæ were added to the colony. Examinations were made several times during the summer of 1910. No Calosoma larvæ or molted skins were found in the colony, but several were secured in the area surrounding it. In the southern part of the town the beetles have become well established, having spread from the colony at Wellesley.

West Newbury.—On July 8, 1910, 200 Calosoma larvæ were liberated in woodland near the top of Pipe Stave Hill.

Westwood.—On July 9, 1910, 200 Calosoma larvæ were liberated in badly infested woodland.

Weymouth.—On July 19, 1909, 200 Calosoma larvæ were liberated in woodland off Commercial Street, Weymouth. The colony was visited several times in 1910, and on July 6 a beetle and 33 larvæ were found. Later in the season molted skins were found to be very abundant in this colony.

Wilmington.—On June 25, 1910, 100 Calosoma larvæ were liberated in woodland about one-half mile from the railroad station. June 30, 100 more larvæ were added to this colony. In 1910 beetles were found in the southern part of the town that had spread from a colony planted at North Woburn in 1907.

Winchester.—On May 8, 1906, Mr. Titus liberated 41 beetles in wood and brush land off High Street. During the winter most of the woodland was cut off, and although careful examinations were made during the summers of 1907, 1908, and 1909 no Calosoma beetles or larvæ were found in the center of the colony, but in 1910 molted skins were found about one half mile north of where the liberation was made.

Woburn.—On July 31, 1907, 23 male and 24 female beetles were liberated in the piece of woodland which had been partially stripped by gipsy moth caterpillars near North Woburn. On August 2, 25 pairs of beetles were added to this colony. Larvæ were found during the summer of 1908, and in 1909 a number of beetles was discovered in the colony and molted skins of the larvæ were found a mile distant. In 1910 the colony had spread over a much larger area, extending throughout the northern part of Woburn and into the towns of Wilmington and Burlington.

COLONIES OF CALOSOMA LIBERATED IN MAINE.

July 22, 1908, 100 Calosoma larvæ were shipped by express to Capt. E. E. Philbrook, Portland, Me. They were packed separately in glass tubes with earth and were liberated by him in Kittery and

Wells. Subsequent examinations have shown that the places selected for making liberations were not particularly suitable for the purpose, as the infestations were so scattering that a sufficient quantity of food was not available for the development of the larvæ.

Kittery.—On July 24, 1908, 15 Calosoma larvæ were liberated near Thaxters Station, under some oak trees upon which were some gipsy moth caterpillars. A wall near the base of these trees had been burned out before the planting was made. Later examinations during the year failed to reveal the presence of the Calosoma beetles and very few gipsy moths remained.

No beetles have been recovered from this colony.

July 25, 1908, 25 Calosoma larvæ were liberated on a large willow on the grounds of the Portsmouth Navy Yard. This tree was not badly infested, so there evidently was not sufficient food for the larvæ. No beetles have since been found in this planting.

July 31, 1908, 100 Calosoma larvæ were liberated on a small island of trees in the salt marsh. Gipsy moth caterpillars and pupæ were scarce at this time. Several examinations have been made since that time, but no Calosoma beetles have been recovered.

Wells.—On July 25, 1908, 20 Calosoma larvæ were liberated around fruit trees infested with the gipsy moth. Caterpillars were scarce on account of the careful handwork that was being done. No beetles have since been recovered. On examining the trees in the summer of 1910, it was not possible to find either the gipsy moth caterpillars or pupæ.

York.—On July 24, 1908, 30 Calosoma larvæ were liberated in woodland slightly infested with the gipsy moth. Although several examinations have since been made, no Calosoma beetles have been found.

COLONY OF CALOSOMA LIBERATED IN NEW HAMPSHIRE.[1]

July 31, 1909, 100 Calosoma larvæ were liberated in woodland near the Sandwich-Tamworth line, which was being defoliated by *Heterocampa guttivitta.* The gipsy moth had not been found in this region, but it was desired to see whether the Calosoma beetles would feed on Heterocampa and survive the winter.

An examination was made August 24, 1910, but no Calosoma beetles were found. Heterocampa larvæ were very scarce throughout this section of the State.

ECONOMIC IMPORTANCE OF CALOSOMA SYCOPHANTA.

The preceding pages show conclusively that this beneficial species, *Calosoma sycophanta,* is firmly established in eastern Massachusetts. The data also show that although in most cases some traces of the insect's presence have been found the year following planting, it takes three years or more before they are sufficiently abundant to attract attention.

For this reason the beetles have not been found by many residents of the district infested with the gipsy moth. The question of the part which this insect is destined to play in controlling the gipsy

[1] Molted skins of *sycophanta* larvæ were found in August, 1910, at Plaistow, N. H. The adults must have migrated from some of the Massachusetts colonies.

moth is one which must be settled by future developments rather than by prophecy or pure speculation.

The feeding period of the beetle and its larvæ corresponds closely with that of the larval and pupal stages of the gipsy moth, and therefore there seems to be no good reason why it will not take prominent rank with the true parasites of this insect and assist and supplement their work.

Its ability to survive and reproduce in New England has been clearly demonstrated when it is stated that as a result of the planting of 13 adult and 14 larval colonies from 1906 to 1908, the presence of the beetle was found over an area of about 9½ square miles in the summer of 1909. During that year 3 adult and 29 larval colonies were liberated and in the summer of 1910 the insects were found scattered over about 106½ square miles in Massachusetts.[1] The aggregate rate of multiplication and dispersion increases with the age of the colonies. Future observations will show the precise value of this insect as an enemy of the gipsy moth.

[1] Examinations in the early summer of 1911 of the regions where liberations have been made indicate that the beetles have continued to increase and spread at a very satisfactory rate.

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